Final

Baseline Ecological Risk Assessment Work Plan for the Quanta Resources Site Operable Unit 2

Prepared for

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Prepared by

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Executive Summary

This Baseline Ecological Risk Assessment (BERA) work plan has been prepared in accordance with the requirements of U.S. Environmental Protection Agency (USEPA) Administrative Order on Consent (AOC) II-CERCLA-2003-2013 for Operable Unit 2 (OU2) of the Quanta Resources Superfund Site, in Edgewater, New Jersey. The proposed BERA is based on USEPA guidance for ecological risk assessments (USEPA, 1992, 1997, 1998).

The Problem Formulation presented in the work plan provides an overview of the site history and habitats at OU2, reviews the conceptual site model, and identifies the assessment/measurement endpoints and the receptors identified for evaluation in the ERA. The Preliminary Screening evaluates the currently available data for the assessment endpoints identified for evaluation, and identifies the additional data that need to be collected during the BERA investigation to fully characterize ecological risk.

The screening evaluation for benthic invertebrates indicates there may be some potential for risk to benthic organisms from the presence of site-related chemicals (primarily polycyclic aromatic hydrocarbons [PAHs]) in surficial sediments. One of the analyses completed was the calculation of Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTUs) for each OU2 remedial investigation sample location. This approach is based on the protection of benthic organisms (invertebrates and fish) and accounts for the biological availability of PAHs in sediment based on total organic carbon concentration in sediment (USEPA, 2003). PAH concentrations in sediment and associated ESBTU values are highest immediately adjacent to the bulkhead along the shoreline of OU2, with concentrations and thus the potential for risk rapidly decreasing with increasing distance from the shoreline to levels approximating those present in upriver/downriver sediments (Figure ES-1). However, there are several uncertainties associated with the screening level risk estimates. The proposed BERA approach for the benthic community will address those uncertainties by focusing the data collection and analysis to (1) further characterize the bioavailability/toxicity of site-related chemicals and identify chemicals causing risk to benthic organisms; (2) further characterize the spatial extent and pattern of site-related ecological risk to benthic organisms; and (3) further differentiate between site-related and non-site-related risks.

The potential for adverse effects to fish was screened using two different screening approaches. Both screens suggest a minimal potential for adverse effects to fish from the presence of PAHs in sediment. However, as part of the conservative assessment of potential ecological risks, fish will be evaluated in the BERA using multiple lines of evidence that will described in detail in a technical memorandum that will supplement this BERA work plan. A preliminary description of the lines of evidence that will be used in the BERA to address fish were provided to the USEPA Biological Technical Assistance Group (BTAG) members during a meeting on May 22, 2008. The technical memorandum providing justification for these lines of evidence, including detailed description of how these lines of evidence will address concerns about early life stage toxicity, will be submitted to USEPA and BTAG members for consideration shortly after the submittal of this BERA work plan. The final

specific approach that will be used to evaluate the potential risks to fish will be based on the agreements with the project team.

The food web models used in the screening evaluation of potential risks to avian and mammalian wildlife indicated no potential for risk to avian herbivores (represented by the Canada goose), avian invertevores (represented by the semipalmated sandpiper), avian omnivores (represented by the black duck), and mammalian omnivores (represented by the raccoon); and minimal potential for risk to avian piscivores (represented by the great blue heron) from the presence of PAHs in sediment. The food web models indicated no potential for risk to any wildlife receptors from the presence of arsenic in sediment. Because of the robust nature of the dataset used and the conservative nature of the risk models, it can be concluded with a high degree of confidence that risks are minimal, have been adequately characterized with the available data, and that additional data are not needed to further characterize risks associated with this potential exposure pathway. Additional sediment chemical analytical data to be collected during the BERA will be screened to ensure that the PAH and arsenic concentrations detected during the BERA approximate those detected during the RI. No additional food web model evaluations will be conducted unless these data indicate that PAH and/or arsenic concentrations are significantly higher, in which case the food web models would be rerun to refine the risk estimates.

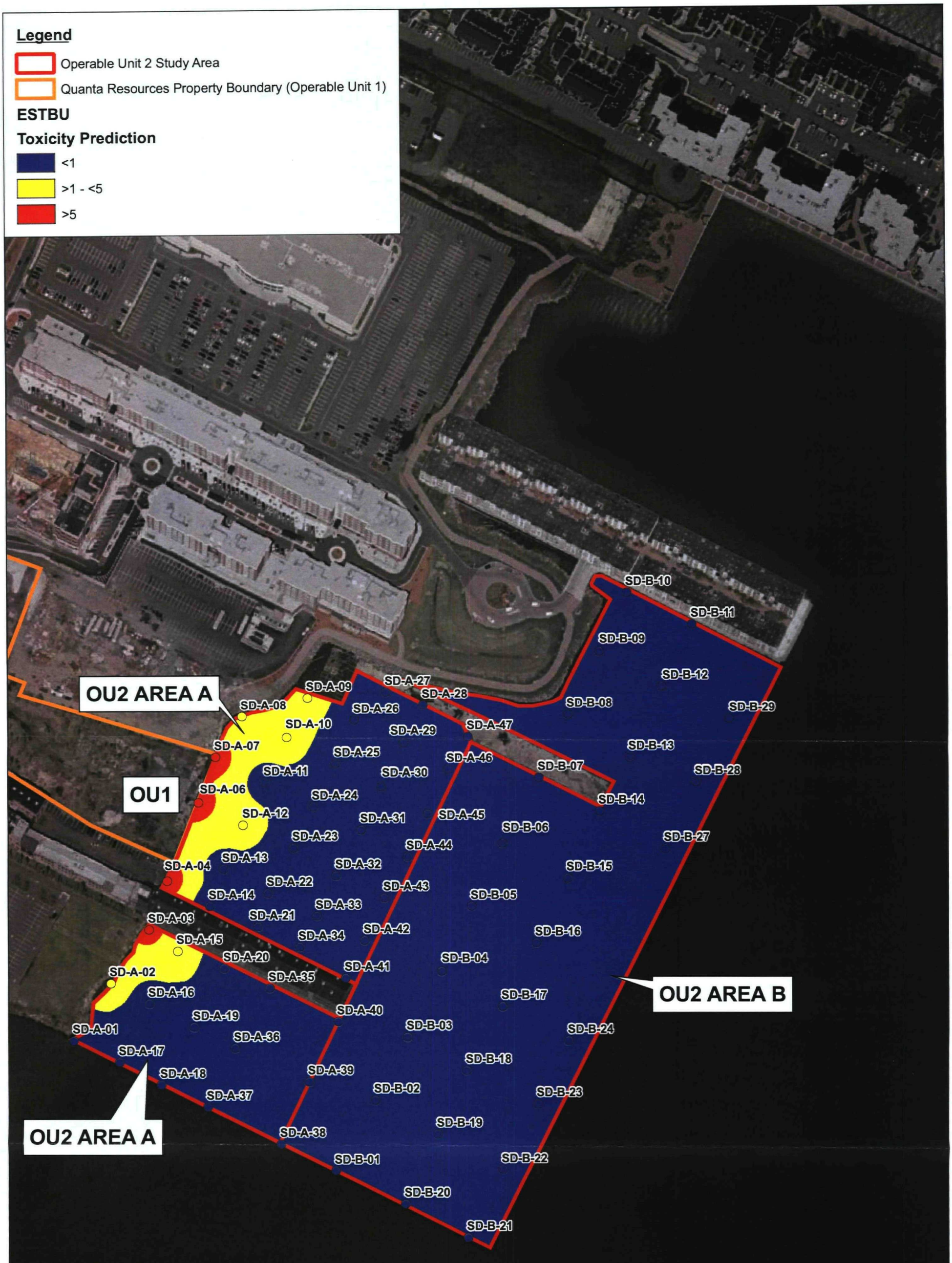
The BERA investigation will build on what is known about risk to ecological receptors and collect the additional data that are necessary to fully characterize ecological risk for the assessment endpoints identified for evaluation. Table ES-1 provides an overview of the approach and analytical methods that will be used in the BERA; Table ES-2 summarizes the field investigation to be conducted in fall 2008. Proposed BERA sample locations in OU2 and the upriver reference areas are provided in Figures ES-2 and ES-3, respectively.

TABLE ES-1
Data to Be Used for the Evaluation of Selected Assessment/Measurement Endpoints

		USEPA ERA (2000)				OU2 RI (2007)	Groundwater/Surface Water Investigation (Proposed Summer 2008)		OU2 BERA Investigation (Proposed Fall 2008)			
	Endpoint	Sediment Chemical/Physical Analysis (OU2 Area A)	14 Day *L. plumulosus* Sediment Bioassay (OU2 Area A)	Benthic Community Analysis (OU2 Area A)	7 Day *M. beryllina* Whole Sediment Fish Bioassay (OU2 Area A)	Sediment Chemical/Physical Analysis (OU2 Areas A and B and Reference)	Sediment Pore Water Chemical Analysis (OU2 Area A)	Surface Water Chemical Analysis (OU2 Area A Groundwater Discharge Zone)	Sediment Chemical/Physical Analysis (OU2 Areas A and B and Reference)	Isotope Dilution - Solid Phase Extraction Sediment Pore Water PAH Chemical Analysis (OU2 Area A)	Benthic Community Analysis (OU2 Areas A and B and Reference)	28 Day *L. plumulosus* Sediment Bioassay (OU2 Areas A and B and Reference)
Assessment	**Measurement**											
Viability of benthic community	Sediment bioassay	—	X	—	—	—	—	—	—	—	—	X
	Comparison of constituent concentrations in sediment with medium-specific toxic effects values	X	—	—	—	X	—	—	X	X	—	—
	Benthic community analysis	—	—	X	—	—	—	—	—	—	X	—
Viability (survival and reproduction) of fish populations	Comparison of constituent concentrations in sediment with medium-specific toxic effects values	X	—	—	—	X	—	—	X	X	—	—
	Fish bioassay	—	—	—	X	—	—	—	—	—	—	—
Viability (survival and reproduction) of avian herbivore populations	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	X	—	—	—	X	—	—	X	—	—	—
Viability (survival and reproduction) of avian invertevore populations	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	X	—	—	—	X	—	—	X	—	—	—
Viability (survival and reproduction) of avian piscivore populations	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	X	—	—	—	X	—	—	X	—	—	—
Viability (survival and reproduction) of avian omnivore populations	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	X	—	—	—	X	—	—	X	—	—	—
Viability (survival and reproduction) of mammalian omnivore populations	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	X	—	—	—	X	—	—	X	—	—	—

TABLE ES-2
Summary of BERA Field Investigation

Analysis	Number of Sample Locations		
	OU2 Area A	OU2 Area B	Reference
Sediment chemical/physical analysis	9	1	10
Isotope dilution–solid phase extraction sediment pore water PAH chemical analysis	9	1	10
Benthic community analysis	9	1	10
28-day *L. plumulosus* sediment bioassay	9	1	10



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Revised Summary of ESBTUs Using Site Specific Uncertainty Factor

Quanta Resources Superfund Site Edgewater, New Jersey

10/1/2008 | **FIGURE ES-1**

\\wave\proj\GIS\Honeywell\Quanta\Reports\332898_PSCR\MapDocs\OU2_ECO\Including_North_Area\BERA_OU2\4-1 PAH Distribution in Surface Sediments Summary of ESBTUs_Oct012008.mxd 10/1/2008 pdesareg

Legend

- Operable Unit 2 Study Area
- Quanta Resources Property Boundary (Operable Unit 1)

ESTBU

Toxicity Prediction

- <1
- >1 - <5
- >5
- Proposed Sample Location

OU2 AREA A

OU1

OU2 AREA B

OU2 AREA A

SD-A-08A, SD-A-09, SD-A-08, SD-A-10, SD-A-07, SD-A-25, SD-A-11, SD-A-06, SD-A-12, SD-A-04, SD-A-32, SD-A-16, SD-A-18A, SD-A-36, SD-A-03, SD-A-15, SD-A-02, SD-A-01, SD-A-17, SD-A-18, SD-A-37, SD-A-38, SD-A-39, SD-A-40, SD-A-41, SD-A-42, SD-A-34, SD-A-33, SD-A-21, SD-A-14, SD-A-22, SD-A-13, SD-A-23, SD-A-24, SD-A-31, SD-A-30, SD-A-26, SD-A-27, SD-A-28, SD-A-29, SD-A-47, SD-A-46, SD-A-45, SD-A-44, SD-A-43, SD-A-35, SD-A-20, SD-A-19

SD-B-09A, SD-B-10, SD-B-11, SD-B-09, SD-B-12, SD-B-08, SD-B-13A, SD-B-29, SD-B-13, SD-B-28, SD-B-07, SD-B-06, SD-B-14, SD-B-27, SD-B-15, SD-B-05, SD-B-16, SD-B-04, SD-B-17, SD-B-03, SD-B-24, SD-B-18, SD-B-02, SD-B-23, SD-B-19, SD-B-01, SD-B-22, SD-B-20, SD-B-21

N

0 100 200

Feet

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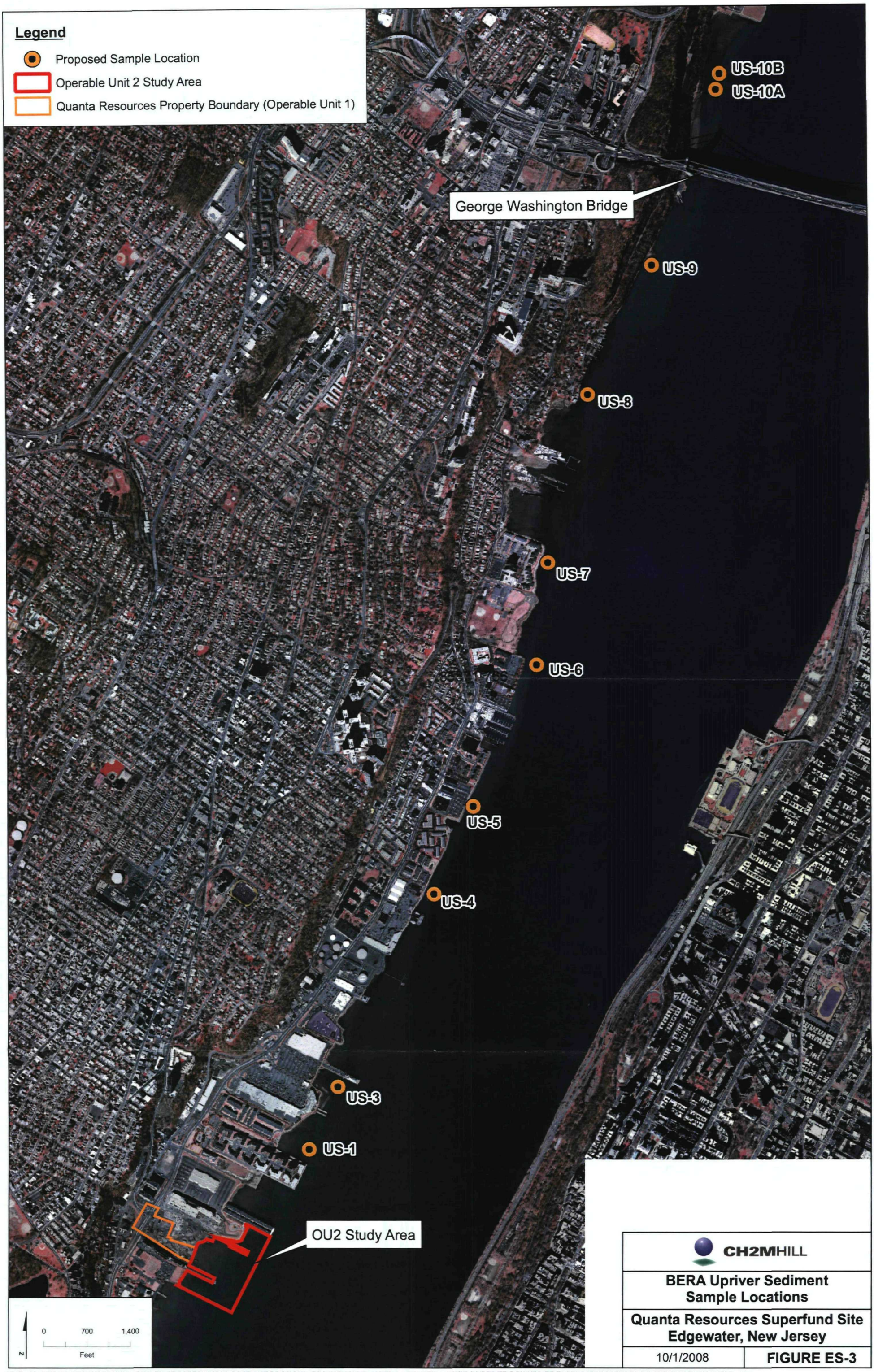
Revised BERA OU2 Sample Locations

Quanta Resources Superfund Site
Edgewater, New Jersey

10/1/2008 | **FIGURE ES-2**

MKE \\WAVE\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\332898_PSCR\MAPDOCS\OU2_ECO\INCLUDING_NORTH_AREA\BERA_OU2\XX_QUANTA_BERA_OU2_SAMPLE_LOCATIONS_01Oct2008.MXD 10/1/2008 pdesareg



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BERA Upriver Sediment Sample Locations

Quanta Resources Superfund Site Edgewater, New Jersey

10/1/2008 | **FIGURE ES-3**

MKE \\WAVE\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\332898_PSCR\MAPDOCS\OU2_ECO\INCLUDING_NORTH_AREA\BERA_OU2\5-2 UPRIVER DOWNRIVER RI SEDIMENT SAMPLE LOCATIONS.MXD 10/01/2008 pdesareg

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Abbreviations and Acronyms

ANOVA	analysis of variance
AOC	Administrative Order on Consent
BERA	Baseline Ecological Risk Assessment
BTAG	Biological Technical Assistance Group
CSM	conceptual site model
EE/CA	Engineering Evaluation/Cost Analysis
ERA	Ecological Risk Assessment
ESBTU	Equilibrium Partitioning Sediment Benchmark Toxic Units
ID-SPME	Isotope dilution-solid phase microextraction
NAPL	non-aqueous phase liquid
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
OU2	Operable Unit 2
PAH	polycyclic aromatic hydrocarbon
PCBs	polychlorinated biphenyls
RI	Remedial Investigation
SAV	submerged aquatic vegetation
TarGOST™	Tar Specific Green Optical Screening Tool
TOC	total organic carbon
TU	toxic unit

SECTION 1

Introduction

1.1 Project Description

This Baseline Ecological Risk Assessment (BERA) work plan has been prepared in accordance with the requirements of U.S. Environmental Protection Agency (USEPA) Administrative Order on Consent (AOC) II-CERCLA-2003-2013 for Operable Unit 2 (OU2) of the Quanta Resources Superfund Site, in Edgewater, New Jersey. The proposed BERA is based on USEPA guidance for ecological risk assessments (USEPA, 1992, 1997, 1998). The work plan summarizes the status of the previous Ecological Risk Assessment (ERA) work at the site and details the additional data that are necessary to evaluate ecological risks at OU2 and complete Step 7 of the eight-step Superfund Ecological Risk Assessment process (USEPA, 1997).

The primary objectives of the Step 7 BERA investigation are to:

- Provide data that can be used to fill data gaps and fully characterize potential risk to all receptors identified for evaluation in the ERA
- Characterize the spatial extent and pattern of site-related ecological risk
- Characterize the bioavailability/toxicity of site-related chemicals and identify chemicals causing risk
- Differentiate between site-related and non-site-related risks

1.2 Site History

The Quanta Resources Site is on the western shore of the Hudson River, at 163 River Road, Edgewater, New Jersey (Figure 1-1). Former industrial properties border the site on the north and south. The site was used for coal tar refining from 1930 to 1974, and waste oil reprocessing from 1974 to 1981 (CH2M HILL, 2005). These activities led to the release of non-aqueous phase liquid (NAPL) and other site-related chemicals to surface and subsurface soils, groundwater, and near-shore sediment adjacent to the site. The upland part of the site (OU1) is backfilled with 10 or more feet of non-native fill and has a wooden pile bulkhead along the shoreline. The portion of the Hudson River immediately adjacent to OU1 (OU2) has been potentially impacted by historic site activities. The Site was listed on USEPA's National Priorities List on September 5, 2002, and has been assigned CERCLIS ID NJ000606442.

Existing data for OU2 indicate that NAPL occurs as lenses interbedded with silt and that concentrations of polycyclic aromatic hydrocarbons (PAHs) in sediment are elevated in areas where NAPL is found. Concentrations of other chemicals appear to be either uniformly distributed, or highest adjacent to the bulkhead. In addition to contaminants from

the site, OU2 sediments may be affected by urban runoff and upstream and/or downstream sources of contamination.

1.3 Past Investigations

The following sections briefly summarize investigations conducted at OU2 that are relevant to the planning and development of the BERA site investigation.

1.3.1 Investigations Prior to 2000

Only limited sampling was conducted in the OU2 area prior to 2000. Between 1984 and 1988, several removal actions were completed by Honeywell (formerly named AlliedSignal) at the OU1 area under USEPA oversight. These actions included the removal of approximately 1.35 million gallons of oil and approximately 1.5 million gallons of coal tar and petroleum/oily wastes from onsite storage tanks, and the removal of some shallow soil and underground piping. The removal actions were assessed by USEPA in 1992 through the collection and analysis of site media, including a limited number of sediment samples.

Between 1992 and the present, several additional sampling events were completed under the USEPA Removal Program. In 1997, a hydrocarbon sheen became intermittently observable at the waterfront. Honeywell conducted a Remedial Site Investigation at the Site between 1998 and 1999, which included the collection of sediment samples from the Hudson River. An Engineering Evaluation/Cost Analysis (EE/CA) report was subsequently submitted to USEPA in November 1999; it was revised/finalized in 2001 (GeoSyntec, 2001). Based on this EE/CA, USEPA made several recommendations for interim actions and requested that Honeywell to do an "ecological evaluation" in the tidal mud flats of the Hudson River.

1.3.2 Ecological Risk Assessment (USEPA, 2000)

An ecological risk assessment investigation was conducted by USEPA in the spring of 2000 to initially characterize the media and pathways by which ecological receptors could be exposed to chemicals at OU2. Site investigation activities included the collection of the following:

- Surface (0 to 6 inches) and subsurface (6 to 12 inches) sediment samples for bioassays with the benthic-dwelling amphipod *Leptocheirus plumulosus* (14-day acute test), bioassays with the silverside minnow (*Menidia beryllina*) (7-day solid phase flow through test), and chemical analysis
- Benthic community analysis samples

The bioassays indicated a limited potential for adverse effects to benthic organisms and fish in the area immediately adjacent to the bulkhead. The potential for risk decreased rapidly with increasing distance from the bulkhead. The benthic community analysis indicated the presence of a stressed benthic community in the study. However, only a limited number of samples was collected, and no reference samples were taken; it could not be determined if the benthic communities differed from benthic communities occurring throughout this urbanized watershed.

1.3.3 OU2 Remedial Investigation (CH2M HILL, 2007a)

Remedial Investigation (RI) field activities were performed in the late fall of 2006. The objectives of the RI were the following:

- Characterize potential sediment impacts associated with former industrial activities at the Quanta Resources property
- Define the nature and extent of site-related potential chemicals of interest, and delineate the impacts caused by the release of these chemicals to the sediments
- Collect data that can be used to evaluate the potential for ecological and human health impacts resulting from the former industrial processes at this property
- Develop supplemental data to address data gaps within the investigations conducted to date to determine the need for and allow a screening of appropriate remedial alternatives, and the development of a refined conceptual site model (CSM)

To meet with these objectives, the RI included the following data collection activities:

- Bathymetric and geophysical surveys (side-scan sonar, sub-bottom, and magnetometer)
- Field screening to delineate the extent of coal tar impacted sediment using Tar Specific Green Optical Screening Tool (TarGOST™) and confirmatory sampling to verify TarGOST™ results
- Surface (0 to 6 inches) and subsurface (up to 30 feet) sediment sampling for chemical/physical analyses
- Chemical fingerprinting

A detailed description of the RI approach is presented in CH2M HILL (2007a).

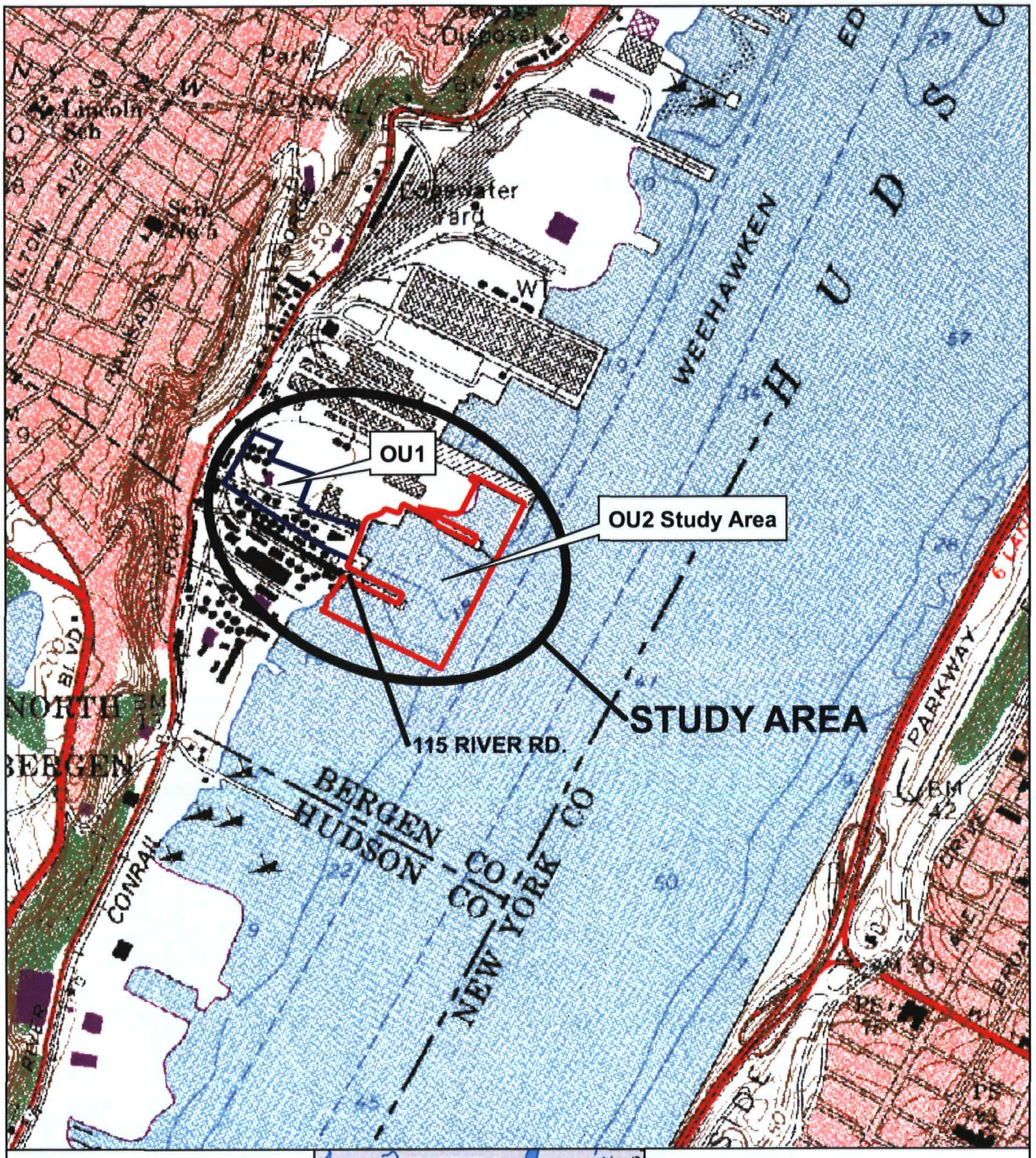
The results of the RI indicated that PAHs are present at higher concentrations in near-shore OU2 surface sediments, relative to upriver and downriver sediments, and that there may be the potential for these chemicals to represent an ecological risk, particularly in the area immediately adjacent to the bulkheaded shoreline, where the highest PAH concentrations were detected.

1.4 Document Organization

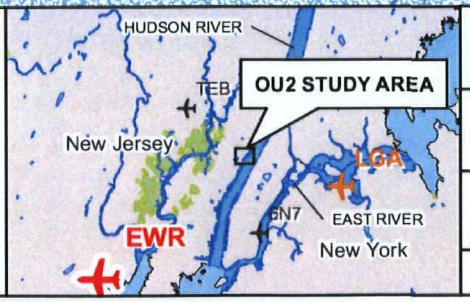
The remainder of this work plan is organized as follows:

- Section 2, Problem Formulation, provides an overview of the site history and habitats at OU2, reviews the conceptual site model, and identifies the assessment/measurement endpoints and the receptors identified for evaluation in the ERA.
- Section 3, Preliminary Screening, screens the currently available data for the assessment endpoints identified for evaluation and identifies the additional data that needs to be collected during the BERA investigation to fully characterize ecological risk.
- Section 4, Proposed Baseline Risk Assessment Analysis Plan, provides an overview of the BERA investigation and how the collected data will be evaluated in the BERA risk characterization.

- Section 5, Data Needs, provides a detailed description of the process that will be used to collect and analyze the samples collected during the BERA.
- Section 6 is the references.



Map Source:
Central Park, NY-NJ,
U.S.G.S.
7.5 Min. Quad



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Study Area Location Map

Quanta Resources Superfund Site
Edgewater, New Jersey

6/13/08 | **FIGURE 1-1**

File Path: E:\GIS\Honeywell\Quanta\Reports\332898_PSCR\MapDocs\PSCR_Report\1-01_Study_Area_Location_Map.mxdDate: 6/13/08, User: FCain

SECTION 2

Revised Problem Formulation

A problem formulation establishes the goals, scope, and focus of the ERA. It is included in this work plan to clarify what is known about potential ecological resources at this Site and to provide a basis for the proposed BERA investigation. The following briefly summarizes the site history and environmental setting of OU2 in terms of the habitats and biota known or likely to be present and the types of chemicals present in ecologically relevant media. A conceptual model is then developed that describes the chemical sources, transport pathways, exposure media, exposure pathways and routes, and ecological receptors. Assessment endpoints are developed to identify receptors for which complete exposure pathways exist and the methods that will be used to evaluate risk to those receptors.

The following revised problem formulation builds on the problem formulation developed in the previous ERA work (USEPA, 2000) and was developed based on discussions with the Region 2 Biological Technical Assistance Group (BTAG) during a meeting on May 22, 2008.

2.1 Ecological Setting and Habitats

The following section provides a summary of the ecological setting, habitats, and wildlife likely to be present in the OU2 area. A detailed description of the ecological resources occurring in the Hudson River system in the area around the site is presented in Appendix A.

The OU2 area is a continuous tidal mudflat that extends eastward of the facility into the Hudson River. Although the sediments adjacent to the bulkheads and piers were historically dredged to allow barge access to the site, these areas have filled with sediment after maintenance dredging was discontinued (Parsons, 2005). Approximately 500 feet of the tidal mud flat is exposed during low tide, whereas the mud flat is flooded by approximately 6.5 feet of water during high tide. The mud flat is composed of silt to clayey silt. No submerged aquatic vegetation (SAV) is present on the mud flat in the areas on or surrounding OU2. Oily sheens have been observed in the mud flats adjacent to the Quanta Resources property, and an absorbent boom is maintained on the tidal flat approximately 125 feet from the shore to control the sheens (CH2M HILL, 2007a). Shoreline habitats associated with the Hudson River in the area around the Site, as well as most of the habitats from Manhattan north to beyond Croton-on-Hudson, have been extensively disturbed from industrial, commercial, and residential development that has bulkheaded and filled substantial areas.

Benthic community analyses conducted in the sediments around OU2 indicates the presence of multiple, primarily shallow-dwelling taxa consisting of oligocheates, nemerteans, amphipods, isopods, polycheates, and bivalves, with oligocheates representing the dominant taxa. The benthic community throughout much of the New York Harbor is characterized as "stressed" (USEPA, 1998, 2000), which can most likely be attributed to the urban nature of this habitat.

The lower Hudson River estuary, defined from the Battery at the southern tip of Manhattan north to Stony Point at the northern end of Haverstraw Bay, is ranked as one of the most productive systems on the northern Atlantic coast for fisheries (USFWS, 1997). Many marine spawners use the lower estuary as a nursery area for early critical life stages of these fish species, and the area inclusive of OU2 has been identified by the National Oceanic and Atmospheric Administration (NOAA) as Essential Fish Habitat for one or more species.[1] The mudflats in the OU2 area, however, do not contain SAV, are exposed during much of the tidal cycle, and are likely to be of only limited value to early-life-stage fish species.

The New York Harbor lies within the Atlantic Flyway, a major migratory pathway for birds, and provides important resting and feeding habitats during the spring and fall migrations (USACOE, 1999). The area on the Hudson River between Jersey City and Edgewater (river miles 1.5 to 8.8) is noted to have significant concentrations of wintering waterfowl such as canvasback (*Aythya valisneria*), scaup (*Athya* spp.), mergansers (*Mergus* spp.), mallard (*Anas platyrhynchos*), and Canada goose (*Branta canadensis*) (USFWS, 1997), and these species have potential to use the mudflats associated with OU2.

A NOAA letter dated January 26, 2006, regarding the Endangered Species Act, the Fish and Wildlife Coordination Act, and the Magnuson-Stevens Fisher Conservation and Management Act indicated that the shortnose sturgeon may occur in an area around Quanta OU2. However, the shortnose sturgeon is an anadromous, euryhaline fish, and although the shortnose can be found throughout the Hudson River system, eggs, larvae, and juveniles are unlikely to inhabit the waters in the vicinity of OU2 because spawning occurs in freshwater, over 100 miles upstream (Dadswell et al., 1984; Hoff et al., 1988). Adults are expected to occur only within the portion of the Hudson River adjacent to OU2 while migrating to or from their preferred spawning, nursery, or overwintering area upriver. It is highly unlikely that adult shortnose sturgeon would utilize the shallow flats during migration because they prefer deep water with high-velocity currents.

A USFWS letter dated January 26, 2006, regarding the Endangered Species Act indicated that except for the occasional transient bald eagle (*Haliaeetus leucocephalis*), no other federally listed or proposed endangered flora or fauna is known to occur within the vicinity of Quanta OU2. The bald eagle was removed from the federal threatened and endangered species list on August 9, 2007, on the basis of its recovery across the nation and the determination that it no longer needs federal protection.

Few terrestrial mammals are likely to occur at the Quanta OU2 site due to the developed and bulkheaded shoreline and lack of preferred habitat surrounding the site. Only a limited number of highly urbanized species (e.g., raccoon, muskrat) would be expected to occur in the area.

2.2 Source Areas, Pathways, and Exposure Media

The primary sources of contamination to OU2 are related to the coal tar processing and oil recycling activities that occurred in OU1 from the late 1800s to 1981. Chemical constituents

[1] http://www.nero.noaa.gov/hcd/webintro.html.

released during these activities may have been transported from OU1 to OU2 via the following pathways:

- Direct discharges from underground piping
- Seepage of NAPL from OU1 soils into the river sediments
- Surficial runoff from OU1
- Direct release of NAPL to the river via spills from barges during loading and unloading operations.

All of the primary sources of contamination from OU1 have been removed (CH2M HILL, 2007b).

Potentially active secondary sources of contamination to OU2 include the migration of NAPL from OU1 north of the wooden bulkhead, and discharge of contaminated groundwater into the near shore sediments. These potential migration pathways are being addressed in the development and evaluation of remedial alternatives for OU1. The potential erosion and transport of contaminated soils from OU1 to OU2 is considered to be insignificant given that OU1 has low topographic relief and is mostly covered by asphalt, concrete, vegetation, gravel, and standing water. Sediments in OU2 may also be impacted by contamination from sources that are not related to the Quanta site, including historical activities on adjacent properties and other potential upstream and downstream sources. A summary of the potential transport pathways and exposure media are shown on Figure 2-1.

Field investigations of OU2 have identified the presence of coal tar and other chemical constituents in sediment (CH2M HILL, 2007a). Where observed, coal tar occurred in discontinuous pockets, lenses, and thin laminae in clayey silt sediment. Coal tar impacted sediment appears to occur to a distance of approximately 300 ft east of the shoreline, at depths ranging from about 5 feet to more than 50 feet below the sediment surface. Coal tar impacted sediments are not continuous with coal tar impacted soils at OU1. The most frequently detected chemical constituents in surface sediment (i.e., detected in more than 50 percent of the samples collected from OU2) are PAHs, polychlorinated biphenyls (PCBs), bis(2-ethylhexyl)phthalate, carbazole, and inorganic constituents (arsenic, chromium, copper, lead, nickel, zinc, and mercury) (CH2M HILL, 2007b).

Some of the chemicals measured at the site, however, may reflect urban inputs, rather than site-related chemicals. CH2M HILL (2007b) compared chemical concentrations detected in the RI sediment samples collected from OU2 with chemical concentrations detected in reference samples in order to identify site-related chemicals, and differentiate them from chemicals occurring in sediments as a result of non-site-related urban inputs. Potentially site-related chemicals were identified by statistically comparing the chemical concentrations detected in the surface sediments (0–0.5 feet) of the OU2 area with those detected in the upriver and downriver sediment samples. This comparison, detailed in CH2M HILL (2007b), focused on the most frequently detected chemicals (i.e., those detected in $\geq$ 50 percent of the samples). The results of this comparison indicated that PAHs are present at higher concentrations in near shore OU2 surface sediments, relative to upriver and downriver sediments. Arsenic is also a potential concern based on the results of the OU1 RI

(CH2M HILL, 2007b). Based on these findings, the evaluation of potential risk associated with PAHs and arsenic will be the focus of the BERA investigation.

A chemical-fingerprinting study conducted as part of the OU2 RI (CH2M HILL, 2007b) evaluated potential impacts of site-related coal tar in Hudson River sediment in the vicinity of the Quanta Resources property. Overall, the results of the chemical-fingerprinting analyses indicated the presence of a substantial hydrocarbon background signature in Hudson River sediments. The background signature comprises a mixture of pyrogenic (combustion related), petrogenic (petroleum related), and biogenic (naturally occurring) PAHs. Samples collected immediately adjacent to the bulkhead show evidence of site-related coal tar impacts. Samples from upstream, across the river, and farther out in the OU2 embayment had a background signature and showed no evidence of site-related coal tar. Samples from two of the upriver stations had elevated levels of petroleum hydrocarbons not related to the Quanta Resources property. Samples from three downstream stations had a mixture of background hydrocarbons and low levels of coal tar or creosote; however, the source relationships of the coal tar in these samples were not obvious.

An exposure pathway links a source of contamination with one or more receptors. A potential for risk can occur only if at least one complete exposure pathway exists for a receptor. Figure 2-1 shows the potentially complete exposure pathways for ecological receptors at OU2. The primary complete exposure pathways at OU2 are to aquatic life and semiaquatic wildlife (e.g., great blue heron) via direct or indirect exposure to sediment or surface water. A more detailed description of the aquatic life and semiaquatic wildlife occurring at OU2 is presented in the following section.

2.3 Receptors and Exposure Routes

2.3.1 Ecological Receptor Groups

A literature-based review was conducted to characterize the habitats and wildlife potentially occurring in the Hudson River around OU2. The results of this review are presented in Appendix A. The following ecological receptor groups were identified for evaluation in the ERA based on the review:

- Benthic invertebrates—The tidal flats adjacent to the Site are composed of unconsolidated sediments of silt to clayey silt and have the potential to contain a variety of benthic invertebrates. Benthic community surveys conducted throughout the lower Hudson River indicate these tidal habitats are dominated by benthic invertebrates that occur primarily in shallow sediments and that the dominant organisms present in this environment are typical of those found in urbanized/industrialized river systems.
- Fish—The finfish communities in waters associated with upper New York Harbor support a variety of both juvenile and adult estuarine, marine, and anadromous fish species. The lower Hudson River estuary is ranked among one of the most productive fishery systems on the northern Atlantic coast, and portions of this system are likely to provide habitat for early-stage planktonic fish species.
- Avian wildlife—New York Harbor lies within the Atlantic Flyway and provides resting and feeding habitats during spring and fall migrations and for wintering waterfowl. The

absence of surrounding terrestrial habitats, however, will limit the use of this habitat by most avian species.

- Mammalian wildlife—The highly developed upland habitats and the bulkheaded shorelines around the Site will limit the presence of mammals. Only a limited number of highly urbanized species are expected to occur in these habitat areas.

2.3.2 Exposure Routes

An exposure route describes the specific mechanism(s) by which a receptor may be exposed to a chemical present in an environmental medium. The most common exposure routes are dermal contact, direct uptake, ingestion, and inhalation. The most important exposure routes for lower trophic level aquatic receptors (benthic invertebrates) and fish is direct contact with surface sediment and surface water, whereas the potential exposure routes for wildlife at OU2 are as follows:

- Incidental ingestion of contaminated abiotic media (sediment) during feeding or preening activities
- Direct ingestion of contaminated water
- Ingestion of prey that have accumulated chemicals
- Dermal contact with contaminated abiotic media

2.4 Assessment and Measurement Endpoints

Ecological risk endpoints define ecological attributes that are to be protected (assessment endpoints) and measurable characteristics of those attributes (measurement endpoints) that can be used to gauge the degree of impact that has occurred or could occur. Assessment endpoints most often relate to attributes of biological populations or communities and focus the risk assessment on particular components of the ecosystem that could be adversely affected by contaminants from a site (USEPA, 1997). Assessment endpoints contain an entity (e.g., fish-eating birds) and an attribute of that entity (e.g., survival rate).

Because of the complexity of natural systems, it is generally not possible to directly assess the potential impacts to all ecological receptors present within an area. Therefore, receptor species (e.g., great blue heron) or species groups (e.g., fish) are often selected as surrogates to evaluate potential risks to larger components of the ecological community, or guilds (e.g., piscivorous birds), represented in the assessment endpoints (e.g., survival and reproduction of piscivorous birds).

Assessment endpoints, measurement endpoints, surrogate species, and risk questions were identified based on consideration of the habitats and ecological receptors potentially occurring onsite and are summarized in Table 2-1.

The following assessment endpoints are proposed:

- Viability of benthic community
- Viability (survival and reproduction) of fish populations
- Viability (survival and reproduction) of avian herbivore populations

- Viability (survival and reproduction) of avian invertevore populations
- Viability (survival and reproduction) of avian piscivore populations
- Viability (survival and reproduction) of avian omnivore populations
- Viability (survival and reproduction) of mammalian omnivore populations

Based on the proposed assessment endpoints the following risk questions were developed:

- Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the benthic community structure and function?
- Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the fish population structure and function?
- Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the avian herbivore population structure and function?
- Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the avian invertevore population structure and function?
- Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the avian piscivore population structure and function?
- Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the avian omnivore population structure and function?
- Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the mammalian omnivore population structure and function?

Measurement endpoints were developed to address the above risk questions. The following measurement endpoints are proposed to assess the potential for unacceptable risk at OU2:

- Benthic invertebrates – A weight-of-evidence approach will be used that integrates (1) whole sediment bioassays, (2) comparison of constituent concentrations in sediment with medium-specific toxic effects values, and (3) benthic community analysis in OU2 and reference areas
- Fish – A weight-of-evidence approach will be used that integrates (1) comparison of constituent concentrations in sediment with medium-specific toxic effects values in onsite and reference areas and (2) fish bioassay
- Avian herbivore populations – Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values
- Avian invertevore populations – Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values
- Avian piscivore populations – Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values
- Avian omnivore populations – Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values

- Mammalian omnivore populations—Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values

The measurement endpoints for the OU2 ERA will incorporate data from all applicable investigations conducted in the OU2 area to evaluate the potential for adverse effects to ecological receptors. Accordingly, the ERA will include evaluation of applicable data from the following investigations, in addition to the data that will be collected during the BERA investigation:

- USEPA ERA site investigation conducted in May 2000
- RI conducted October through December 2006
- Groundwater-surface water investigation planned for summer 2008

The data from each of these investigations that will be incorporated into the evaluation of each assessment endpoint is summarized in Table 2-2. A detailed description of the data to be collected during the BERA is presented in the following sections of this work plan.

As indicated in the selected assessment endpoints, the ERA will focus on the evaluation of potential risk to wildlife from the ingestion of chemicals accumulated in prey and in sediment. In addition to this exposure pathway, there is some potential for wildlife to be exposed to PAHs via direct exposure (i.e., fouling) and inhalation. The potential for exposure via these pathways is considered small on the basis of the weathered nature of the PAHs at this site. Most notably, the volatile components of the PAHs, which are the components that could cause inhalation toxicity, are highly transient and are unlikely to remain beyond a few hours in weathering PAHs (Leighton, 2000). These exposure pathways are considered highly unlikely to adversely affect wildlife, but will be considered in the BERA for completeness. Few applicable toxicological data are available, and these potential exposure pathways will therefore only be evaluated qualitatively.

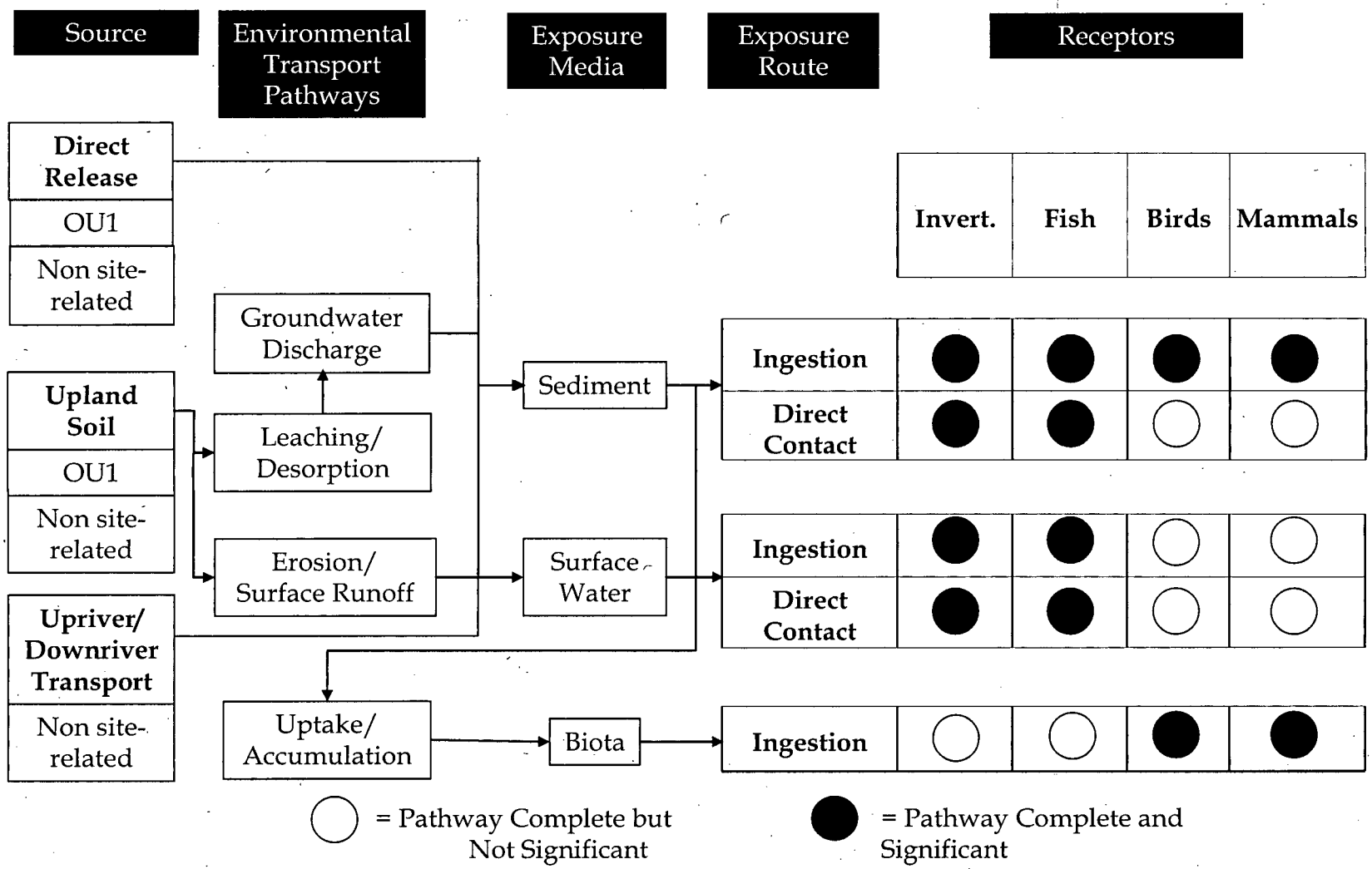
TABLE 2-1
Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints for the Ecological Risk Assessment

Assessment Endpoint	Risk Question	Measurement Endpoint	Receptor
Viability of benthic community	Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the benthic community structure and function?	(1) Sediment bioassays, (2) comparison of constituent concentrations in sediment with medium-specific toxic effects values, and (3) benthic community analysis in OU2 and reference areas	Benthic invertebrate community
Viability (survival and reproduction) of fish populations	Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the fish population structure and function?	(1) Comparison of constituent concentrations in sediment with medium-specific toxic effects values in onsite and reference areas, and (2) fish bioassay	Fish (focus on essential fish species)
Viability (survival and reproduction) of avian herbivore populations	Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the avian herbivore population structure and function?	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	Canada goose
Viability (survival and reproduction) of avian invertevore populations	Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the avian invertevore population structure and function?	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	Semipalmated Sandpiper
Viability (survival and reproduction) of avian piscivore populations	Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the avian piscivore population structure and function?	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	Great blue heron
Viability (survival and reproduction) of avian omnivore populations	Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the avian omnivore population structure and function?	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	Black duck
Viability (survival and reproduction) of mammalian omnivore populations	Are site-related chemicals (PAHs and/or arsenic) impacting the viability of the mammalian omnivore population structure and function?	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	Raccoon

TABLE 2-2
Data to Be Used for the Evaluation of Selected Assessment/Measurement Endpoints

Endpoint		USEPA ERA (2000)				OU2 RI (2007)	Groundwater/Surface Water Investigation (Proposed Summer 2008)		OU2 BERA Investigation (Proposed Fall 2008)			
Assessment	Measurement	Sediment Chemical/Physical Analysis (OU2 Area A)	14 Day *L. plumulosus* Sediment Bioassay (OU2 Area A)	Benthic Community Analysis (OU2 Area A)	7 Day *M. beryllina* Whole Sediment Fish Bioassay (OU2 Area A)	Sediment Chemical/Physical Analysis (OU2 Areas A and B and Reference)	Sediment Pore Water Chemical Analysis (OU2 Area A)	Surface Water Chemical Analysis (OU2 Area A Groundwater Discharge Zone)	Sediment Chemical/Physical Analysis (OU2 Areas A and B and Reference)	Isotope Dilution - Solid Phase Extraction Sediment Pore Water PAH Chemical Analysis (OU2 Area A)	Benthic Community Analysis (OU2 Areas A and B and Reference)	28 Day L. plumulosus Sediment Bioassay (OU2 Areas A and B and Reference)
Viability of benthic community	Sediment bioassay	—	X	—	—	—	—	—	—	—	—	X
	Comparison of constituent concentrations in sediment with medium-specific toxic effects values	X	—	—	—	X	—	—	X	X	—	—
	Benthic community analysis	—	—	X	—	—	—	—	—	—	X	—
Viability (survival and reproduction) of fish populations	Comparison of constituent concentrations in sediment with medium-specific toxic effects values	X	—	—	—	X	—	—	X	X	—	—
	Fish bioassay	—	—	—	X	—	—	—	—	—	—	—
Viability (survival and reproduction) of avian herbivore populations	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	X	—	—	—	X	—	—	X	—	—	—
Viability (survival and reproduction) of avian invertevore populations	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	X	—	—	—	X	—	—	X	—	—	—
Viability (survival and reproduction) of avian piscivore populations	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	X	—	—	—	X	—	—	X	—	—	—
Viability (survival and reproduction) of avian omnivore populations	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	X	—	—	—	X	—	—	X	—	—	—
Viability (survival and reproduction) of mammalian omnivore populations	Comparison of modeled dietary intakes using sediment concentrations with literature-based ingestion toxicity reference values	X	—	—	—	X	—	—	X	—	—	—

Ecological Conceptual Site Model for OU2



CH2MHILL	
Ecological Conceptual Site Model	
Quanta Resources Superfund Site Edgewater, New Jersey	
6/13/2008	FIGURE 2-1

SECTION 3

Preliminary Risk Screening

All available data that are relevant to the evaluation of ecological risks will be considered for the Step 7 evaluation. The objective of the BERA investigation is to provide the additional data necessary to fill data gaps and reduce uncertainties surrounding the final estimate of risk to ecological receptors.

As discussed in previous sections, surface sediment and surface water represent the primary exposure pathways by which ecological receptors could be exposed to chemicals in OU2. Risks to ecological receptors from the presence of chemicals in sediments were preliminarily evaluated with the limited data set collected during the EPA (2000) ERA investigation. A much larger number of surface sediment samples was collected throughout Areas A and B during the RI (CH2M HILL, 2007b); however, these data have not previously been screened for the evaluation of ecological risk. The chemical analytical data collected during the RI were accordingly screened for their potential to represent an ecological risk. This screen considered risk to all the assessment endpoints identified for evaluation in the ERA, with the exception of risk to fish populations. The results of this screen are presented in Appendix B.

The following sections incorporate the results of this preliminary screen along with consideration of applicable data from the earlier USEPA ERA (2000), to characterize the status of the evaluation of each assessment endpoint identified for consideration in the ERA. The overall objective of this section is to summarize what is known about ecological risk for each assessment endpoint, identify data gaps, and establish the basis for the BERA site investigation. The status of the fish assessment endpoint evaluation is discussed within this section.

3.1 Benthic Invertebrates

The USEPA, as part of the ERA conducted in spring 2000, collected six surface (0 to 6 inches) sediment samples for whole sediment bioassays with the benthic-dwelling amphipod *Leptocheirus plumulosus* (14-day acute test), chemical analysis, and benthic community analysis (Figure 3-1). In addition, sediment from one sample location (Location 1) was tested in a dilution series: 100, 50, 10, and 1 percent, using clean sediment as the diluent. Significant reductions in *L. plumulosus* survival occurred in whole sediment samples collected from Locations 1 and 3, both of which are adjacent to the bulkhead, when compared to the laboratory control. Significant reductions in *L. plumulosus* survival also occurred in the 10 percent and 50 percent sediment dilution samples from Location 1 when compared to the laboratory control. *L. plumulosus* growth was significantly reduced in all samples.

The benthic community analysis conducted as part of the ERA also indicated the presence of a stressed benthic community throughout the investigated area. However, no reference samples were collected, and it could not be determined if these stressed benthic

communities differed from benthic communities occurring throughout this urbanized watershed.

The RI provided a much larger chemical analytical dataset for evaluation, with 46 surface sediment samples collected from Area A and 27 surface sediment samples collected from Area B. Potential risks to benthic invertebrates were evaluated (Appendix B) by screening chemical concentrations detected in sediment during the RI against literature-based toxic effects values. An additional analysis was completed to determine the potential for risk from PAHs. The Equilibrium Partitioning Sediment Benchmark Toxic Units (ESBTU), which is protective of benthic organisms (invertebrates and fish), was calculated for each sample location (USEPA, 2003). The ESBTU approach accounts for the biological availability of PAHs in sediment based on total organic carbon (TOC) concentration in sediment.

Consistent with the outcome of the ERA (USEPA, 2000), the results of this screening indicates there may be some potential for risk to benthic organisms from the presence of site-related chemicals (primarily PAHs) in surficial sediments. PAH concentrations and associated risks are highest immediately adjacent to the bulkhead, with concentrations and thus the potential for risk rapidly decreasing to levels approximating those present in upriver/downriver sediments with increasing distance from the shoreline.

The results of this screening, coupled with the USEPA (2000) ERA, suggest there is some potential for adverse effect to benthic organisms, most notably in the area immediately adjacent to the bulkhead, where the highest PAH concentrations were detected. However, there are a number of uncertainties associated with the estimate of risk. The focus of the BERA investigation will be to build on the existing database in order to fill the key data gaps, reduce uncertainty, and facilitate a more detailed characterization of potential site-related risks to the benthic community. The BERA will focus on providing additional data that can be used to fully characterize risks associated with the following data gaps that have been identified for the evaluation of risks to benthic organisms:

Characterize the Bioavailability/Toxicity of Site-Related Chemicals and Identify Chemicals Causing Risk to Benthic Organisms.

With the exception of the limited bioassay and benthic community samples collected during the ERA (USEPA, 2000), the majority of the evaluation completed during the ERA (USEPA, 2000) and RI (2007b) relied on chemical analytical measures. Although the resulting data can be used in conjunction with literature-based toxic effects values to screen the potential for adverse effects, these chemical measures do not fully account for the bioavailability of chemicals in the environment, and literature-based toxicity values frequently overestimate the potential for adverse effects to benthic organisms. ESBTUs account for the reduction in bioavailability based on the presence of organic carbon in sediment, but do not account for the reduction in bioavailability associated with the adsorption of PAHs to suspended colloidal materials. The BERA investigation will focus on the use of analytical methods which account for the bioavailability of chemicals in sediment. The approach will use bioassays, community analyses, and chemical analytical methodologies which account for the form and bioavailability of chemicals in the environment.

Characterize the Spatial Extent and Pattern of Site-Related Ecological Risk to Benthic Organisms.

The ERA (USEPA, 2000) focused on the evaluation of ecological risk to benthic organisms with a limited number of sediment samples collected from a localized area of OU2, adjacent to the bulkheaded shoreline. Although chemical concentrations were quantified in the broader OU2 Area (Areas A and B) during the RI investigation, the potential effect or risk of these chemicals to benthic communities has not been fully characterized in the broader OU2 Area. The BERA investigation will focus on collecting additional data that can be used, in conjunction with the existing data, to further characterize the spatial extent and pattern of potential site-related risk throughout the OU2 area.

Differentiate Between Site-Related and Non-Site-Related Risks.
The ERA (USEPA, 2000) indicated some potential for adverse effects to benthic organisms in localized areas immediately adjacent to OU1. This ERA did not, however, characterize potential ecological risks in non-site-impacted areas of this estuarine river system. Risks within non-site-impacted areas must be characterized in order to differentiate between levels of risk that could be occurring as the result of an urbanized environment from the level of risk that is caused by site-related factors. Although the RI evaluated chemical concentrations in upriver and downriver sediments, in areas that are unlikely to be site-impacted, it did not focus on the evaluation of risk to benthic organisms in these areas. Additional investigation is needed to fully characterize risks in both OU2 and in areas that are not site-impacted to differentiate between the level and type of risks in potentially site-impacted and non-site-impacted areas.

3.2 Fish Populations

The USEPA, as part of the ERA conducted in spring 2000, collected six surface (0 to 6 inches) sediment samples for whole sediment bioassays with the silverside minnow (*Menidia beryllina*) (7-day solid phase flow through test) (Figure 3-1). The *M. beryllina* fish bioassay indicated a reduction in survival in one (Location 1) of the six surface sediment samples tested when compared to the laboratory control. There were no other significant effects observed for this bioassay when tested with surface sediment.

The RI provided a much larger chemical analytical dataset for evaluation, with 46 surface sediment samples collected from Area A and 27 surface sediment samples collected from Area B for chemical analysis. The potential for adverse effects to fish was screened in Appendix B using the RI sediment chemical analytical data and two different screening approaches. The PAH data were screened with a fish-based sediment toxicity value that was derived using the ESBTU approach and toxicity data presented in USEPA (2003). A literature-based food web model was also used to evaluate risk to fish from the potential ingestion of PAHs in the food web. Both screens suggest a minimal potential for adverse effect to fish from the presence of PAHs in sediment. However, as part of the conservative assessment of potential ecological risks, fish will be evaluated in the BERA using multiple lines of evidence that will described in detail in a technical memorandum that will supplement this BERA work plan. A preliminary description of the lines of evidence that will be used in the BERA to address fish were provided to the USEPA BTAG members during a meeting on May 22, 2008. The technical memorandum providing justification for these lines of evidence, including detailed description of how these lines of evidence will address concerns about early life stage toxicity, will be submitted to USEPA and BTAG

members for consideration shortly after the submittal of this BERA work plan. The final specific approach that will be used to evaluate the potential risks to fish will be based on the agreements with the project team.

3.3 Avian and Mammalian Wildlife

The RI provided a robust chemical analytical dataset for the evaluation of potential risks to wildlife, with 46 surface sediment samples collected from Area A and 27 surface sediment samples collected from Area B. The 73 surface sediment samples collected from Areas A and B were evaluated with a screening-level food web model (Appendix B) to determine the potential for adverse effects to wildlife from the ingestion of chemicals that have accumulated in the prey. The food web models used many conservative assumptions (e.g., bioaccumulation factors, ingestion rates, and 95UCL sediment chemical concentrations) that are consistent with those used in a Screening Ecological Risk Assessment to ensure that risks are not underestimated. It is likely, however, that risks are overestimated by this model. Accordingly, an indication of little or no risks provides a high degree of confidence that risks are not occurring, while an indication of risk suggests that further evaluation may be warranted. The food web models used in the screening evaluation indicated no potential for risk (HQ < 1) to avian herbivores (represented by Canada goose), avian invertevores (represented by semipalmated sandpiper), avian omnivores (represented by black duck), and mammalian omnivores (represented by raccoon) and minimal potential for risk (HQ = 3 based on comparison to No Observed Adverse Effect Level) to avian piscivores (represented by Great Blue Heron) from dietary exposure to PAHs via the ingestion of prey and sediment. The food web models indicated no potential for risk to any wildlife receptors from dietary exposure to arsenic via the ingestion of prey and sediment.

Based on the conservative nature of the model assumptions, the robust chemical analytical dataset used for evaluation, and the minimal risk indicated with the food web models, it is concluded there is little risk to wildlife via ingestion, and that no additional data or risk calculations are needed to fully characterize in the BERA these risks to wildlife receptors. Accordingly, it is anticipated that no additional evaluation of wildlife receptors is needed. However, as a conservative measure, the additional sediment chemical analytical data to be collected during the BERA will be evaluated to ensure that PAH and arsenic concentrations detected during the BERA approximate those detected during the RI. No additional food web model evaluation will be conducted unless these data indicate that PAH and/or arsenic concentrations are significantly higher and that the food web models need to be rerun to confirm the previous risk model outcomes.

CH2MHILL

USEPA ERA Sediment Sample Locations

Quanta Resources Superfund Site
Edgewater, New Jersey

6/13/2008	**Figure 3-1**

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SECTION 4

Proposed Baseline Risk Assessment Analysis Plan

The objective of the BERA investigation is to build on what is known about risk to ecological receptors and collect the additional data that are necessary to fully characterize ecological risk for the assessment endpoints identified for evaluation in the ERA. The BERA will focus on the evaluation of PAHs, and to a lesser extent arsenic, both of which have been identified as potentially site-related chemicals. However, the BERA will also include the evaluation of a range of chemicals that are not suspected to be site-related. These chemicals will be included in the analysis to provide additional information about the overall condition of the OU2 area sediments relative to the reference area and to facilitate the interpretation of the BERA investigation.

The following sections provide an overview of the approach and analytical methods that will be used in the BERA to fully characterize risk to each the assessment endpoints/receptor groups identified for evaluation in the ERA.

4.1 Assessment Endpoint—Viability of Benthic Community

A screen of the available sediments data, coupled with the USEPA (2000) ERA, suggests there is some potential for adverse effect to benthic organisms, with the greatest potential for adverse effect occurring in the area immediately adjacent to the bulkhead, where the highest PAH concentrations were detected. However, there are several uncertainties associated with the estimate of risk. The proposed assessment approach for the benthic community is designed to address those uncertainties by focusing the data collection and analysis to further:

- Characterize the bioavailability/toxicity of site-related chemicals and identify chemicals causing risk to benthic organisms
- Characterize the spatial extent and pattern of site-related ecological risk to benthic organisms
- Differentiate between site-related and non-site-related risks

Potential risks to the benthic community will be assessed using a weight-of-evidence approach that integrates whole sediment toxicity tests, in situ benthic community analysis and comparison of constituent concentrations in sediment with medium-specific toxic effects values. The following data will be collected as part of the BERA investigation to fully characterize risks to the benthic community:

- Benthic invertebrate (*Leptocheirus plumulosus*) bioassay data for surficial (0 to 6 inches[2]) sediment samples collected from OU2 and upriver locations: The objective of the sediment bioassay is to obtain the quantitative data necessary to determine whether exposure to surficial sediment from potentially site-impacted areas in the OU2 Area is toxic to benthic organisms, to understand the spatial scale of any potential effects, and to characterize the variable(s) likely to be causing the adverse effect, if observed.

- Benthic community analysis samples collected from OU2 and upriver locations: The benthic community analysis provides a measure of the actual biological effects of contaminants in situ by characterizing the richness of the benthic community and by comparing benthic community richness between potentially site-impacted and non-site-impacted areas.

- Chemical analytical and physical data for surficial (0 to 6 inches) sediment and pore water samples collected from OU2 and upriver locations: The sediment chemical and supporting physical analytical data will be used to determine potential exposures levels of benthic organisms to chemicals (most notably PAHs and arsenic) in surficial sediment (0 to 6 inches) in both potentially site-impacted and upriver areas. These data will be used as part of the weight-of-evidence approach and will support the interpretation of the bioassay outcomes and benthic community analyses by providing data that can be used to identify the variable(s) that might be causing any observed effects. The chemical/physical analytical data also will be used, in conjunction with the RI data, to understand the spatial scale of the exposure and potential effects.

The above analyses will be conducted on all sediment samples collected during the BERA. The specifics of the assessment approach and OU2 sample locations were selected based primarily on the distribution of PAHs and arsenic (characterized during the RI; Figures 4-1 and 4-2, respectively) and results of the Refined Risk Screening calculations (Appendix B). Based on that assessment, the following sample areas were identified:

- **Locations immediately adjacent to the bulkhead**—The area adjacent to the bulkhead was determined during the RI (CH2M HILL, 2007b) to have some of the highest PAH concentrations and the greatest potential for PAH risk to benthic invertebrates, as determined by PAH ESBTUs (Appendix B).

- **Locations throughout the remaining portions of Areas A and B**—PAH concentrations suggest a limited potential for risk to mostly sensitive species, though there remains uncertainty about the toxicity of sediments present in this area.

- **Locations that are not site impacted**—Reference sediment samples will be collected from stations that range from approximately 1,500 feet north of OU2 to just north of the George Washington Bridge. These locations were selected as reference samples for the BERA investigation based on a review of the RI (CH2M HILL, 2007b) reference sample data, which indicates they have physical characteristics similar to the sediments in the OU2 area and that they have not been impacted by localized sources of contamination.

[2] Zero to 6 inches is the standard depth considered to represent the Biotic Zone for the purposes of toxicity testing; below this depth, sediments become anoxic, and high levels of sulfide may be toxic to indwelling benthic organisms.

The following sections provide details of each line-of-evidence proposed for the benthic community assessment.

4.1.1 Benthic Invertebrate Bioassays

Direct sediment toxicity will be measured using the *L. plumulosus* 28-day sediment test as described in ASTM (2000). Survival, growth, and reproduction data will be collected for each sample and presented as the average of 8 replicate samples.[3] Two types of testing will be conducted:

1. **Whole sediment tests**—Samples collected throughout OU2, away from the bulkhead, and reference sample locations will be tested with undiluted sediments.

2. **Dilution series tests**—A limited number of sediment samples from locations immediately adjacent to the bulkhead will be collected for dilution series testing (100, 50, 10, and 1 percent of site sediment mixed with clean control sediment) and presented as the average of eight sample replicate samples in each dilution. The purpose of the testing is to establish effects concentrations at locations where some of the highest PAH concentrations are in sediment.

The following sections summarize the analyses that will be conducted on the whole sediment sample tests and the dilution series tests.

Whole Sediment Test Analyses

Performance criteria specific to this bioassay are presented in USEPA (2001). The bioassay outcomes will be evaluated according to the statistical process summarized in Figure 4-3 and discussed in this section.

The data first will be tested for normality and homogeneity. Based on the outcomes of these analyses, data transformations may be applied, and it will be determined whether the data should be tested with parametric or non-parametric statistics.

Data from each OU2 area and upriver sample first will be compared to the laboratory control samples to determine if there are significant and absolute differences in survival, growth, and/or reproduction between river samples and the laboratory control. In comparing controls to the individual river stations, the null hypothesis is that the average replicate survival or growth in the sampling station sediment is no different from the average replicate survival or growth in the laboratory control. The alpha level (or p value) for the test will be adjusted to account for multiple comparisons to retain an overall rejection rate of 0.05. The following conclusions will be made depending on the test outcome:

- **The p value of the test statistic is less than the adjusted p value**—The null hypothesis is rejected, and it will be concluded that the bioassay outcome indicates a potential for adverse effect in the tested parameter (survival, growth, and/or reproduction) at that river sample location.

[3] The relative weight-of-evidence will be assigned in the sequence survival > reproduction > growth because in some species of amphipods both reproduction and growth are adversely affected by the quality of the organic matter in the sediment, independent of any contaminants. Therefore, reproduction and growth are more uncertain measurement endpoints upon which to judge potential remedial actions.

- **The *p* value of the test statistic is greater than the adjusted alpha level**—The null hypothesis is not rejected, and it will be concluded there is no significant difference between the river sample and laboratory control.

If any of the OU2 area toxicity test results exhibit toxicity greater than laboratory control tests, an analysis of variance (ANOVA) will be performed to compare upriver and OU2 station results. If ANOVA results exhibit significant differences, posterior tests will be performed to determine where differences between OU2 and up river stations occur. The following conclusions will be made based on the test outcomes:

- The comparison indicates that the OU2 station toxicity significantly exceeds that of the reference area results: It will be concluded there is the potential for site-related adverse affect at that station.
- No OU2 station toxicity results significantly exceed toxicity observed in the reference area: The observed affect to benthic organisms will be considered not to be site-related, but instead will be considered to reflect broader conditions within the river system.

The absolute difference between OU2 station and upriver station results will also be considered. If significant differences between individual OU2 station and upriver station results are observed (based on posterior comparisons), but the OU2 station toxicity is less than 25 percent of the upriver results, then the observed affect will also be considered not to be site-related.

If a bioassay outcome indicates an effect, the following additional analyses will be conducted:

- Spatial relationships of the site-related bioassay results will be qualitatively and quantitatively evaluated. The purpose of this evaluation is to characterize the potential spatial scale of the observed effect. Results will be compared to determine if correlation in organism response with distance from shore or other spatial parameter. Quantitative analyses will be conducted to characterize the chemical or physical variable likely to be causing the effect.
- The relationship between the toxic response and chemical/physical parameter. If there is the potential for site-related adverse affects at any station, quantitative analyses will be conducted to characterize the chemical or physical variable likely to be causing the effect. The level of observed toxic effects, arsenic, and PAH chemical concentrations (both bulk sediment and isotope dilution-solid phase microextraction [ID-SPME] pore water), and physical parameter measures (e.g., TOC, pH, and grain size) in bulk sediment will be evaluated to determine if a relationship can be identified. Simple correlation and multiple regression analyses, supplemented with visual evaluation of single-parameter scatter plots will be used to identify possible relationships. If relationships cannot be determined with arsenic and PAH concentrations, similar evaluations will be expanded to include additional chemicals detected in sediments exhibiting toxic responses.
- If arsenic or PAHs are determined to be potentially contributing to toxicity (or cannot be excluded as not contributing to toxicity), then dose-response analyses using linear or non-linear regression methods will be used to develop a model from which an effect

concentration can be developed. If the cause(s) of an observed effect can be identified, then the expected outcomes will be extrapolated, as appropriate, to make predictions about areas of anticipated impact based on available chemical/physical analytical data collected from surface sediments during the RI and ERA investigations.

Dilution Series Test Analyses

The 100 percent concentration for the dilution series tests will be analyzed in the same manner as samples taken from locations that will not be diluted. Additional evaluation of dilution series samples will be conducted if the undiluted sample indicates a potential for adverse effect, in which case the concentration/toxicity relationship (based on sediment percentages) will be translated into chemical toxicity levels (LC50, EC50, NOECs, or LOECs). If chemical concentrations in the undiluted sample are below screening values and no relationships appear evident, then toxicity values will not be developed.

4.1.2 Benthic Community Structure

Analysis of the benthic community structure will consist of five discrete replicate samples collected at each sample location. Each replicate sample will be sorted separately, and the macroinvertebrates from each of these replicates will be identified to the lowest practical taxonomic level and enumerated. The following benthic community parameters will be calculated for each station to characterize the benthic macroinvertebrate community composition:

- **Total abundance**—Represents the total number of organisms present in the sample and is a measure of total biological activity at that location.
- **Species diversity**—Indicates the variety of species utilizing the habitat and will be expressed as the number of species present or species richness. High abundance and diversity values are generally indicators of a high quality habitat.
- **Number of opportunistic, pollution-tolerant species**—Provides an indicator of impacted communities. Dominance by opportunistic, pollution-tolerant species is typical of stressed or impacted communities. Although dominance by pollution-tolerant species alone does not necessarily indicate that a chemical is causing an adverse effect, when used along with other measure of potential effect and in comparison to the same measure in reference samples, it provides a useful line of evidence with which to evaluate potential impacts to benthic communities. For this investigation, the number of opportunistic/pollution-tolerant species will be calculated from the average number of the polycheate *Streblospio benedicti*, copepod *Capitella* spp., dwarf surf clam *Mulinia lateralis*, and oligochaetes at each station. These species were selected based on their designation as pollution-indicative taxa in the investigation of sediment quality of the NY/NJ Harbor System (USEPA, 1998) and their ability to occur in the type of habitat present at OU2.

Results of the benthic community structure analyses will be evaluated as a component of the overall weight of evidence analysis to determine if there are risks to the benthic community. The three benthic community structure measures will be compared statistically between the site samples and the reference samples to identify if the measures are significantly different for the overall site and reference populations. These measures will also be ranked for each

individual station to provide input into the overall weight of evidence analysis. Stations will be ranked separately for each of the metrics. For example, for total abundance, the station with the lowest total abundance will receive a rank of 1 (most affected) and the station with the highest total abundance will receive a rank of 20.

If potential site-related effects are observed, additional analyses will be conducted to characterize the chemical or physical variable likely to be causing the effect. The specific analyses that will be conducted will depend on the observed effect. However, the relationship between the observed effect and chemical concentration (both bulk sediment and ID-SPME pore water) and physical parameter measures (e.g., TOC, pH, and grain size) in bulk sediment will be evaluated to determine if there is a relationship. Simple correlation and multiple regression analyses and visual evaluation of single-parameter scatter plots will be used to identify possible relationships. If relationships are not identified, the analyses will be expanded to include additional chemicals analyzed for in sediment.

4.1.3 Sediment/Pore Water Chemical and Physical Analysis

The sediment chemical and physical analyses will be used as part of the weight-of-evidence approach to characterize and interpret any effects that are observed in the sediment bioassay and/or benthic community analyses. Surface sediment samples for chemical and physical analyses will be collected concurrently with sediment samples for bulk sediment toxicity testing. Sediment samples will be analyzed for the following:

- **Chemical Analytes: Inorganics, PCBs (Aroclors), VOCs, SVOCs**—In addition to PAHs and arsenic, which are potentially site-related, the sediment chemistry samples are being analyzed for a number of chemicals (e.g., PCBs) that are not suspected to be site-related. These chemicals were included in the analysis to provide additional information about the overall condition of the OU2 area sediments relative to the reference area and to facilitate the interpretation of the bioassay and benthic community structure outcomes, which could be affected by a wide range of chemicals, including non-site-related compounds.

- **Physical Parameters: TOC, grain size**—Sediment grain size and TOC will be analyzed to characterize the physical composition of the collected samples to assess the potential effect of physical composition on chemical bioavailability and to confirm that the physical characteristics of the reference stations closely resemble those of the OU2 sample stations.

- **ID-SPME and analysis of 34 PAHs**—The ID-SPME method provides a means to measure freely dissolved PAHs in small volumes of pore water and provides an indicator of the bioavailability of PAHs in sediment. The 34 PAHs to be analyzed represent the specific nonalkylated and generic alkylated PAHs that have been identified as the most abundant and common PAHs and representative of "total PAHs" (USEPA, 2003). The 34 PAHs will be analyzed in both pore water and whole sediment samples. The sediment pore water PAH concentrations obtained through the ID-SPME analysis will be used to estimate the bioavailable concentrations of PAHs in sediment because comparisons that rely on bulk sediment concentration measures often overestimate bioavailability and ecological risk. The sediment pore water PAH concentrations will be converted to toxic units (TUs), as defined by the USEPA (2003), to

assess potential risk. The whole sediment PAH concentrations will be used for comparison with the corresponding concentrations measured in pore water.

Arsenic and PAH concentrations detected within each sample will be compared to the marine sediment benchmarks listed in Table 4-1. Additional toxics effects values may also be considered if determined to be applicable to this evaluation. Additional parameters analyzed in sediment will be evaluated with the lowest benchmark available from the following sources:

- New Jersey DEP Guidance for Sediment Quality Evaluations
- USEPA Region III BTAG Marine Sediment Screening Benchmarks

4.1.4 Weight of Evidence Evaluation

Following their individual analyses, the sediment bioassay, benthic community structure, and sediment chemistry/physical analyses will be integrated using a weight-of-evidence approach so that overall conclusions to be made about the potential for adverse effects to the benthic community. The lines of evidence to be used for this weight-of-evidence analysis are listed in Table 4-2.

Two methods will be used to compare the lines of evidence in the weight of evidence evaluation: the ranking method and multidimensional scaling. A discussion of these methods follows.

Ranking Method

The ranking method is a simple approach for displaying the relative performance of each station, using the endpoints listed in Table 4-2. Using this approach, the 20 stations (site and reference) will be ranked for each of the measured endpoints. The following measured endpoints will be ranked for each individual line of evidence:

- **Sediment bioassay**: Stations will be ranked for survival, growth, and reproduction. For example, the station with the lowest survival will receive a rank of 1 (most affected) and the station with the highest survival will receive a rank of 20. Growth and reproduction will be ranked using the same approach.

- **Benthic community structure**: Stations will be ranked separately for each of the benthic metrics using the same approach as that used for the sediment toxicity data. For example, for total abundance, the station with the lowest total abundance will receive a rank of 1 (most affected) and the station with the highest total abundance will receive a rank of 20.

- **Sediment chemistry**: Stations will be ranked based on the degree to which the PAH and arsenic concentrations exceed the appropriate effects benchmarks. Separate rankings will be done for arsenic, total PAHs, and PAH ESBTUs. The station with the highest sum of ratios will receive a rank of 1 (most affected) and the station with the lowest sum of ratios will receive a rank of 20 for both measures.

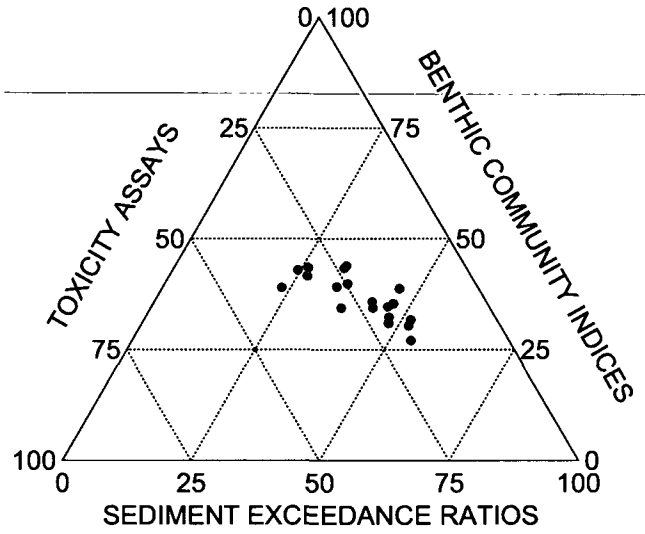
Once the individual parameters for a sample station are ranked, an overall station rank then will be calculated by averaging all of the individual ranks determined for a station. The station rank will be used to characterize the overall condition of that station, relative to the

others. The average rank will be calculated by equally weighting each endpoint measured for each of the three different benthic community measures—sediment bioassay, benthic community structure, and sediment chemistry. This approach will result in a slightly unequal weighting of the different lines of evidence as the three lines of evidence will be available for the sediment bioassays and benthic community structure and only two lines of evidence will be available for the sediment chemistry. Since the sediment bioassays and benthic community structure are considered the more ecologically relevant measures, this unequal weighting is considered appropriate.

The average ranks will be used, along with professional judgment, to sort the stations into poor, intermediate, and good sediment quality categories. In the event that the average ranks do not clearly indicate quality categories, a "critical" value from the distribution will instead be calculated. The critical value will be developed by generating a random distribution of average ranks and comparing values from this distribution with the average ranks calculated for the 20 stations. The 10th percentile from the random average rank distribution will be used as the critical value, below which stations may be considered as having poor sediment quality.

This ranking method works well for combining information across different endpoints. However, the magnitude of the differences among the stations is lost with this simple ranking approach. Therefore, a method that accounts for the magnitude of difference in response between two stations also will be employed.

Univariate distributions of each sediment bioassay, benthic community structure, and sediment chemistry measure will be displayed by plotting rank versus observation to display the shape and variability of measures across the 20 stations. Measures across the three lines of evidence will be aggregated into tri-plots, which exhibit the relative positions of the cases over the three sides of a triad. An example of a tri-plot is presented in the example below.



Example tri-plot summarizing locations. Bioassay, benthic community indices and sediment chemistry exceedance ratios have been normalized across the range observed in each variable over the multiple measures. In this case, subsets, represented by different colors, intermingle in the three sides of the tri-plot, suggesting marginal differences among subsets.

Station comparisons will be performed using the nonparametric Kruskal-Wallis test to compare individual ranks. Where test results are significant, posteriori differences among all possible pairs of stations will be evaluated.

Multivariate Scaling

Once the ranking process has been completed, multivariate scaling (e.g., cluster analyses) will be used to identify stations which are similar for the parameters being evaluated.

The outcome of the weight-of-evidence evaluation will be a designation for each station relating the potential for adverse effects to the benthic community. Each station will be designated as having poor, intermediate, or good sediment quality based on the average rank or by comparison to a critical value. The magnitude of the differences between stations will be used to reinforce these designations. Results from the statistical evaluations will be interpreted spatially by the mapping the resulting designations.

4.2 Assessment Endpoint—Viability of Fish Populations

As discussed in Section 3.2, preliminary screening of the available data collected as part of the USEPA ERA (2000) and the RI (CH2M HILL, 2007b) suggests a minimal potential for adverse effects to fish from exposure to PAHs in sediments. Based on discussions with USEPA BTAG members during a meeting on May 22, 2008, it was determined that further consideration of the fish endpoint would be given prior to determining if additional site data are needed. Based on these discussions, a technical memorandum was developed that describes the BERA approach as it relates to the evaluation of the embryo-larval survival and sustainability of fish populations that could be exposed to site-related chemicals (CH2M HILL and ENVIRON, 2008). The memorandum contains detailed discussions of technical and scientific issues related to the following:

- Fish communities that may be present at OU2, particularly those with regulatory status, such as the Magnuson-Stevens Fishery Conservation and Management Act and the Endangered Species Act
- Sensitivity of fish to polycyclic aromatic hydrocarbons (PAHs), including fish in early life stage (ELS) development (i.e., eggs and larvae), compared to other organisms that may be present at OU2
- USEPA's recommended approach for addressing the toxicity of PAHs to fish and benthic organisms (ESBTU approach), and how this approach is protective of ELS development
- Use of ELS fish sediment bioassays compared to other lines of evidence that are used for evaluating potential risks to fish
- Preliminary screening of OU2 data as a basis for considering the BERA approach for fish and data needed to support this evaluation

This evaluation is ongoing and, consistent with the assessment endpoint identified for evaluation in the ERA, will consider the overall potential for adverse effects to fish populations potentially occurring in the OU2 area. However, the primary focus of the evaluation will be on the evaluation of the following:

- **Fish species for which the OU2 area is identified as Essential Fish Habitat.** The lower Hudson River estuary, inclusive of the OU2 area, has been defined as Essential Fish Habitat for one or more species.
- **Fish species residing in the OU2 area during early life stages.** The lower Hudson River estuary from the Battery at the southern tip of Manhattan north to Stony Point at the northern end of Haverstraw Bay has been ranked as one of the most productive fishery systems on the northern Atlantic coast (USFWS, 1997).

The evaluation of this assessment endpoint will continue in the BERA, where a weight-of-evidence approach that focuses on the following lines of evidence will be used to further build on the existing lines of evidence:

- **Fish bioassay.** Results of the silverside minnow (*Menidia beryllina*) (7-day solid-phase flow-through test) fish bioassay conducted in spring 2000 by USEPA on surface sediment (0 to 6 inches) samples will be incorporated as a line of evidence in the evaluation of risk to fish populations.
- **Sediment toxicity testing using a more-sensitive species with a standard sediment-testing protocol.** Benthic invertebrate (*Leptocheirus plumulosus*) bioassay data for surficial (0 to 6 inches) sediment samples collected from OU2 and upriver locations will be used for this analysis.
- **Chemical analytical and physical data for surficial (0 to 6 inches) sediment and pore water samples collected from OU2 and upriver locations.** The sediment chemical and supporting physical analytical data will be used to determine potential exposure levels of fish and fish embryos to chemicals in surficial sediment in the upriver areas. These data will be used as part of the weight-of-evidence approach. Sediment and pore water data are considered to represent a worst-case exposure scenario for free-living fish and fish larvae. Therefore, the available surface water chemical analytical data will be used in conjunction with the pore water data to estimate more realistic risk outcomes, particularly with reference to teratogenesis associated with exposure to certain PAHs found in the water-soluble fraction of crude oil (Carls et al., 2008). These chemical/physical analytical data also will be used in conjunction with the RI data to understand the spatial scale of the exposure and potential effects.
- **Benthic community analysis results.** Generalizations made using this line of evidence will be considered with regard to the species sensitivity distributions and ELS fish.
- **Spatial/temporal evaluation of species occurrence and habitat usage.** The occurrence of species and their use of the OU2 area will be evaluated to characterize the potential exposure.

The evaluation will also review and consider any additional ELS study information provided by the BTAG. However, consistent with the approach used for the evaluation of risk to benthic organisms, multiple lines of evidence will be used in a weight-of-evidence approach to evaluate the overall potential for adverse effects on fish populations.

4.3 Assessment Endpoint—Viability of Avian and Mammalian Wildlife Populations

As discussed in Section 3.2, the potential for adverse effects to avian and mammalian wildlife receptors from exposure to PAHs and arsenic from the ingestion of prey and sediment was evaluated with screening-level food web models using the sediment chemical analytical data collected during the RI. Appendix B provides a detailed description of these risk model calculations, including the model input parameters and risk outcomes. The food web models used in the screening evaluation indicated no potential for risk (HQ < 1) to avian herbivores (represented by Canada goose), avian invertevores (represented by semi-palmated sandpiper), avian omnivores (represented by black duck), and mammalian omnivores (represented by raccoon), and minimal potential for risk (HQ = 3 based on comparison to No Observed Adverse Effect Level [NOAEL]) to avian piscivores (represented by Great Blue Heron) from dietary exposure to PAHs from the ingestion of prey and sediment. The food web models indicated no potential for risk to any wildlife receptors from exposure to arsenic from the ingestion of prey and sediment. Based on the robust nature of the dataset used for the evaluation, which consisted of 83 surface sediment samples collected from locations throughout Areas A and B, and the conservative nature of the risk models, it can be concluded with a high degree of confidence that risks are minimal, have been adequately characterized with the available data, and that additional data are not needed to further characterize risks associated with this potential exposure pathway. Consistent with the approach discussed in Section 3.2, additional sediment chemical analytical data to be collected during the BERA will be screened to ensure that the PAH and arsenic concentrations detected during the BERA approximate those detected during the RI. No additional food web model evaluations will be conducted unless these data indicate that PAH and/or arsenic concentrations are significantly higher, in which case the food web models would be rerun to refine the risk estimates. Refined risk estimates may also consider refined exposure and effects assumptions in accordance with USEPA methodology (1997, 1999, 2000b, 2001). As discussed in Section 2.4, however, potential risk associated with inhalation and direct exposure of wildlife to PAHs in sediment will be qualitatively evaluated in the BERA.

TABLE 4-1
Benthic Community Sediment Effects Benchmarks

Chemical	Benchmark	Source
Arsenic	8.2 mg/kg	ER-L; Long et al., 1995
Total PAHs (sum of 34)	1 (sediment pore water toxic units)	ESBTU; USEPA, 2003

PEC, probable effect concentration; ESBTU, equilibrium partitioning sediment benchmark toxic unit.

TABLE 4-2
Benthic Community Weight of Evidence Endpoints

Line of Evidence	Endpoint
L. plumulosus bioassays	Survival
	Growth
	Reproduction
Benthic community structure	Total abundance
	Taxa richness
	Percent of taxa that are opportunistic/pollution-tolerant
Sediment chemistry	Arsenic HQ
	Total PAHs toxic unit HQ for sediment pore water

Legend

Operable Unit 2 Study Area

Quanta Resources Property Boundary (Operable Unit 1)

ESTBU

Toxicity Prediction

<1

>1 - <5

>5

OU2 AREA A

OU1

OU2 AREA B

OU2 AREA A

SD-A-01 SD-A-02 SD-A-03 SD-A-04 SD-A-06 SD-A-07 SD-A-08 SD-A-09 SD-A-10 SD-A-11 SD-A-12 SD-A-13 SD-A-14 SD-A-15 SD-A-16 SD-A-17 SD-A-18 SD-A-19 SD-A-20 SD-A-21 SD-A-22 SD-A-23 SD-A-24 SD-A-25 SD-A-26 SD-A-27 SD-A-28 SD-A-29 SD-A-30 SD-A-31 SD-A-32 SD-A-33 SD-A-34 SD-A-35 SD-A-36 SD-A-37 SD-A-38 SD-A-39 SD-A-40 SD-A-41 SD-A-42 SD-A-43 SD-A-44 SD-A-45 SD-A-46 SD-A-47

SD-B-01 SD-B-02 SD-B-03 SD-B-04 SD-B-05 SD-B-06 SD-B-07 SD-B-08 SD-B-09 SD-B-10 SD-B-11 SD-B-12 SD-B-13 SD-B-14 SD-B-15 SD-B-16 SD-B-17 SD-B-18 SD-B-19 SD-B-20 SD-B-21 SD-B-22 SD-B-23 SD-B-24 SD-B-27 SD-B-28 SD-B-29

0 100 200

Feet

N

CH2MHILL

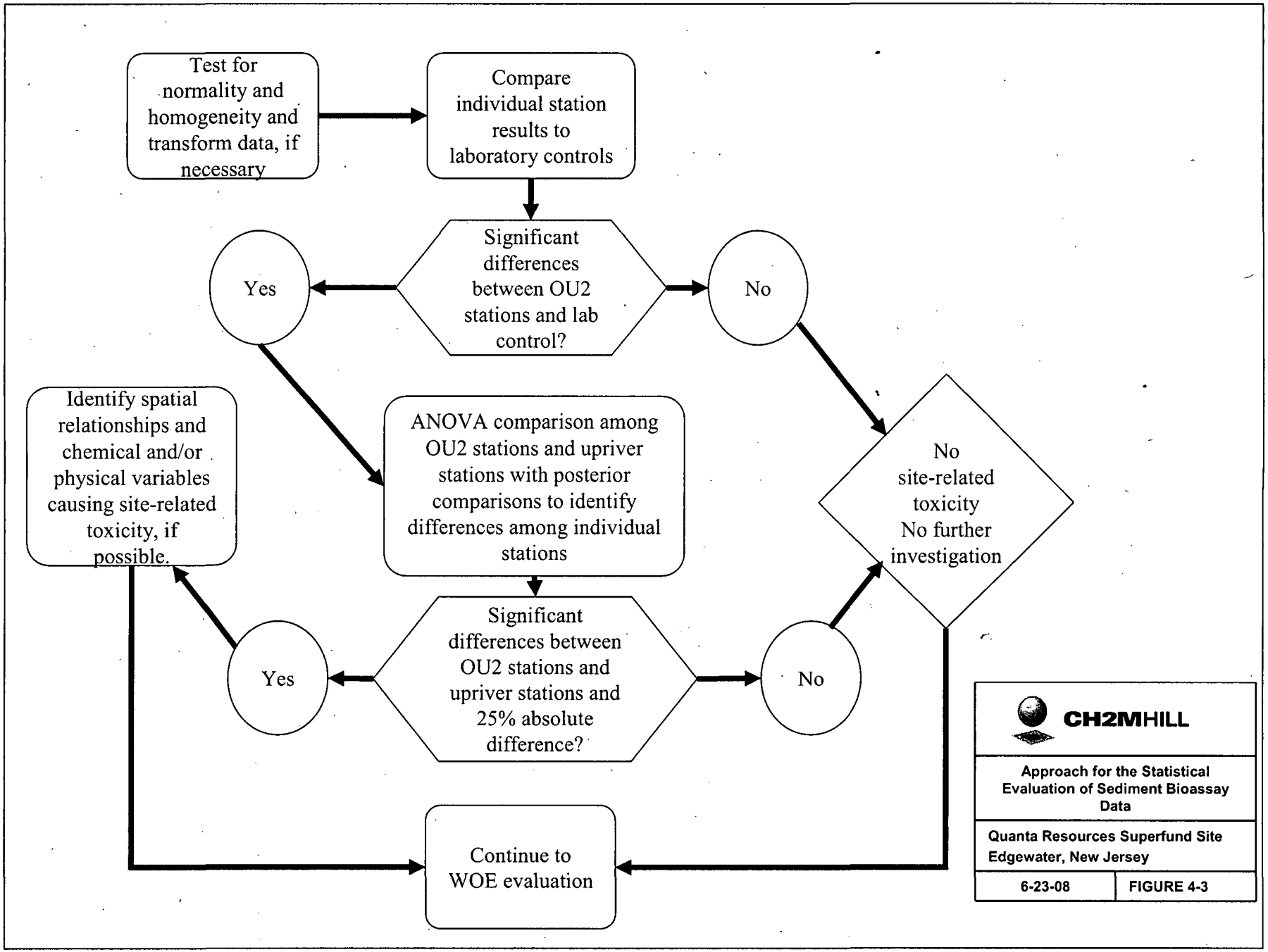
Revised Summary of ESBTUs Using Site Specific Uncertainty Factor

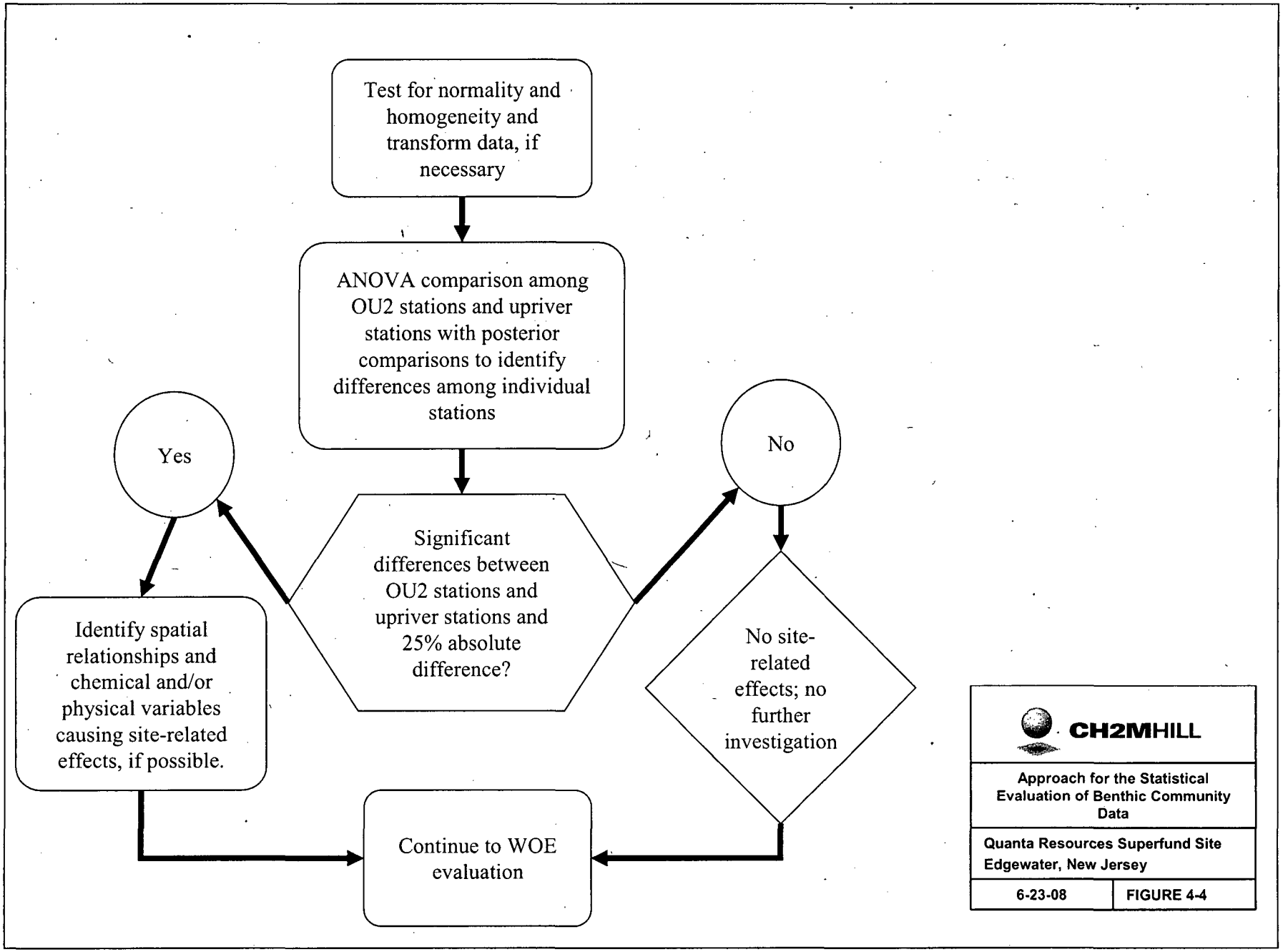
Quanta Resources Superfund Site Edgewater, New Jersey

10/1/2008 | **FIGURE 4-1**

\\wave\proj\GIS\Honeywell\Quanta\Reports\332898_PSCR\MapDocs\OU2_ECO\Including_North_Area\BERA_OU2\4-1 PAH Distribution in Surface Sediments Summary of ESBTUs_Oct012008.mxd 10/1/2008 pdesareg

E:\GIS\Honeywell\Quanta\Reports\332898_PSCR\MapDocs\OU2_ECO\Including_North_Area\BERA_OU2\4-2 Arsenic Distribution in Surface Sediments Summary of PECs.mxd FCain 6/16/08


Test for normality and homogeneity and transform data, if necessary
Compare individual station results to laboratory controls
Significant differences between OU2 stations and lab control?
Yes
No
Identify spatial relationships and chemical and/or physical variables causing site-related toxicity, if possible.
ANOVA comparison among OU2 stations and upriver stations with posterior comparisons to identify differences among individual stations
No site-related toxicity No further investigation
Significant differences between OU2 stations and upriver stations and 25% absolute difference?
Yes
No
Continue to WOE evaluation
CH2MHILL
Approach for the Statistical Evaluation of Sediment Bioassay Data
Quanta Resources Superfund Site
Edgewater, New Jersey
6-23-08
FIGURE 4-3



CH2MHILL

Approach for the Statistical Evaluation of Benthic Community Data

Quanta Resources Superfund Site
Edgewater, New Jersey

6-23-08 | FIGURE 4-4

SECTION 5

Data Needs

The following summarizes the additional data to be collected during the BERA investigation. Section 5.1 identifies the locations and methods that will be used to collect the sediment and benthic community samples. Section 5.2 summarizes the methods that will be used to analyze the sediment samples following collection. The Data Quality Objectives for the collection of the BERA investigation data are presented in Appendix C.

5.1 Sample Collection

5.1.1 Sediment Sample Collection

Ten discrete surface (0 to 6 inches) sediment samples will be collected from OU2 Areas A and B for sediment chemical/physical analysis, pore water chemical analysis, and bioassay testing. The locations of the OU2 area samples are shown in Figure 5-1. Ten additional discrete reference surface sediment samples will be collected from stations ranging from approximately 1,500 feet north of OU2 to just north of the George Washington Bridge. The locations of the reference samples are shown in Figure 5-2.

Surface sediment samples for bioassay analysis will be collected concurrently with sediment samples for bulk sediment chemical/physical testing, with the samples collected for bioassay testing representing a split of the samples collected for chemical/physical analysis. A grab sampler will be used to collect the discrete samples. At each sample location, surface sediment (top 6 inches) will be collected and placed in a decontaminated stainless steel container capable of holding sufficient volume for the analyses. Multiple surface sediment grabs will be collected, if necessary, to obtain the required sample volume. It is estimated that approximately 2 gallons of sediment will need to be collected from each location, with the exception of the two samples that will be collected immediately adjacent to the bulkhead. Additional sediments will be collected from these locations for the bioassay dilution testing. Immediately following collection, sediments from a sample location will be homogenized in the stainless steel container to a consistent color and texture, and the bioassay and chemistry sample containers will be filled with the homogenized sediments. Sediment samples will be shipped on ice at 4°C to the bioassay and chemical analytical laboratories for overnight delivery.

5.1.2 Benthic Community Analysis Sample Collection

Samples for the benthic community analysis will be collected from the same locations as the OU2 area (Figure 5-1) and reference area (Figure 5-1) samples for chemical/physical analytical and bioassay analyses. Samples will be collected using a discrete grab sampler that is applicable to the collection of benthic invertebrates. Five replicate grab samples will be taken at each sample location. The contents of each grab sample will be sieved in the field using a 0.5-μm mesh sieve. Material retained on the sieve will be rinsed into a 500-mL plastic container and preserved with 10 percent formalin solution containing rose bengal

stain. The preserved samples will be stored on ice and shipped to the laboratory for identification and enumeration. Near-bottom water quality parameters (dissolved oxygen, temperature, salinity, and pH) and depth will be measured at each station using a water quality meter.

5.2 Sample Testing and Analysis

5.2.1 Sediment Chemistry

Following receipt by the chemical analytical laboratory, the sediment samples will be analyzed for inorganics, PCBs (Aroclors), VOCs, SVOCs, TOC, and grain size. Laboratory analytical methods to be used are summarized in Table 5-1. Pore water for the ID-SPME analysis will be extracted following delivery of the sample to the chemical analytical laboratory. ID-SPME and analysis of 34 PAHs will be conducted as outlined in USEPA (2003).

5.2.2 Sediment Bioassay

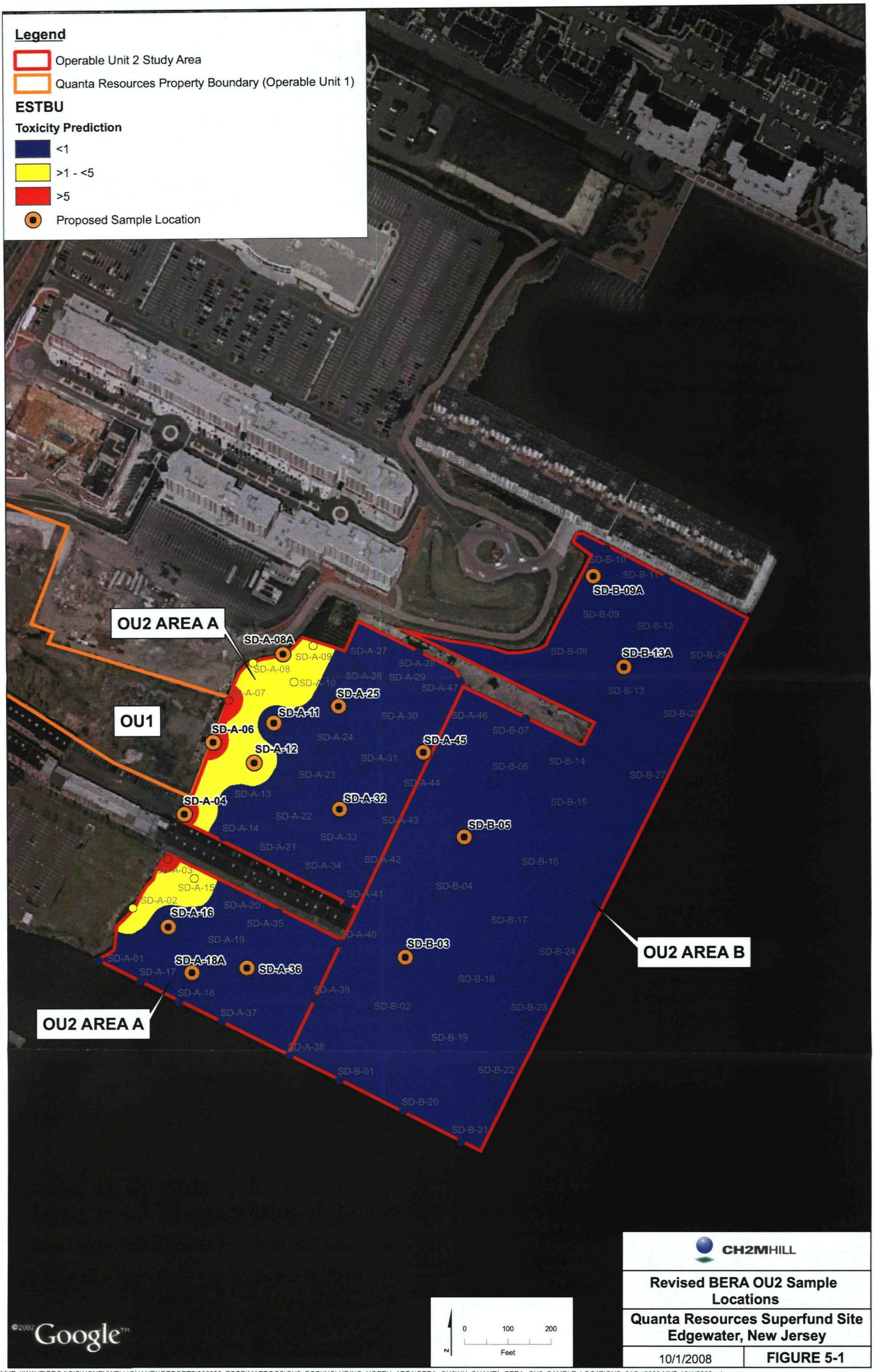
The *L. plumulosus* 28-day survival test will be conducted as described in ASTM (2000). Eight replicates will be tested for each sample and survival, growth, and reproduction will be determined for each replicate. Undiluted sediments will be tested for all collected samples. Dilution series (100, 50, 10, and 1 percent of site sediment mixed with clean control sediment) tests also will be conducted on the two samples collected from locations immediately adjacent to the bulkhead. As for the undiluted samples, each dilution will be tested on eight sample replicates. Performance criteria specific to this bioassay are presented in USEPA (2001).

5.2.3 Benthic Community

Once in the laboratory, the macroinvertebrates collected from each location will be transferred to 70 percent ethanol and identified to the lowest practical taxonomic level and counted. Total abundance, number of taxa, and number of opportunistic pollution-tolerant species will be calculated for each sample location to provide the data necessary for the benthic community analyses described in Section 4.1.2.

TABLE 5-1
Laboratory Analytical Methods

Analysis	Methodology
Inorganics	SW-846 Method 6010B
PCB Aroclors	SW-846 Method 8082
TCL volatiles	SW-846 Method 8260B
Semivolatile organics	SW-846 Method 8270C
TOC	SW-846 Method 9060
Grain size	ASTM method D422
ID-SPME (34 PAHs)	EPA Draft Method 8272



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Legend

- Proposed Sample Location
- Operable Unit 2 Study Area
- Quanta Resources Property Boundary (Operable Unit 1)

US-10B
US-10A
George Washington Bridge
US-9
US-8
US-7
US-6
US-5
US-4
US-3
US-1
OU2 Study Area

0 700 1,400
Feet
N

CH2MHILL

BERA Upriver Sediment Sample Locations

Quanta Resources Superfund Site Edgewater, New Jersey

10/1/2008 | **FIGURE 5-2**

MKE \\WAVE\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\332898_PSCR\MAPDOCS\OU2_ECO\INCLUDING_NORTH_AREA\BERA_OU2\5-2 UPRIVER DOWNRIVER RI SEDIMENT SAMPLE LOCATIONS.MXD 10/01/2008 pdesareg

SECTION 6

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Appendix A
OU2 Habitat Description

OU2 Habitat Description

Introduction

The following information was compiled to assist in accurately defining exposure pathways and receptors at the Quanta site, Operational Unit 2 (OU2), located on the western bank of the Hudson River in Edgewater, New Jersey.

Physical Characteristics

The Hudson River drains New York, and parts of Vermont, Massachusetts, Connecticut and New Jersey. The basin contains three subareas: the upper Hudson from Mt. Marcy to Troy, the Mohawk from Rome to Troy and the lower Hudson from Troy to New York Bay. The Hudson and Mohawk basins are fresh water; the lower Hudson is an estuary with water greater than 1 practical salinity unit (psu) usually below West Point. The Hudson River is a partially mixed estuary with higher salinity water overlain by lower salinity water over a broad stretch of mixing between the river and the ocean. The estuary can be divided into four salinity zones: polyhaline (18.5–30 psu), mesohaline (5–18) oligohaline (0.3–5) and limnetic (<0.3) (Levinton and Waldman 2006). The location of these zones varies seasonally and daily depending on tidal and freshwater inputs. The lower Hudson River estuary zone from Manhattan to Stony Point has very strong semi-diurnal (twice daily) tidal currents and moderate salinities generally in the range of 5 to 30 parts per thousand, but with lower salinities during spring runoff (USFWS 1997).

The lower Hudson estuary, from the Battery at river kilometer 0 (river mile 0) to the New York-New Jersey state line at river kilometer 35 (river mile 22), is fairly narrow, with an average width of about 1,500 meters (5,000 feet), an average depth of about 12 meters (40 feet), and semi-diurnal tides of 1.2 to 1.5 meters (4 to 5 feet). Most of the shoreline habitat, especially from Manhattan north to beyond Croton-on-Hudson, is extensively disturbed from industrial, commercial, and residential development that has bulkheaded and filled substantial areas. The tidal flats adjacent to the Quanta site extends eastward in the Hudson River and is bordered to the west by a concrete bulkhead (USEPA 2000). A boom is located on the tidal flat approximately 125 feet from the bulkhead. Depths at Quanta OU2 range from 0.0 to 28.0 feet

Water Quality

Water quality parameters of temperature (°C), salinity (parts per thousand (ppt)) and dissolved oxygen were collected in Hudson River Park located on the western waterfront of Manhattan from the Battery to 59th Street from June 2002 to June 2004 at eight sampling sites (Bain et al. 2006). This study site is located approximately 5 miles downstream and across the Hudson River from Quanta. Strong seasonal variation in water temperature (Figure A-1) existed with the lowest mean temperature in February (lowest recording = 0°C) and the

highest in August (highest = 25.9°C) of each study year. Surface waters were slightly warmer (paired t-Test, mean difference 0.14°C, p = 0.0049) than bottom waters across all sites. Salinity varied seasonally although the pattern was not as apparent as temperature. Surface water salinity (mean 13.9) ranged from 5.8 to 25.2 ppt. On average bottom water had a salinity of 15.84 ppt and a range of 5.9 to 25.9 ppt through the study period (Figure A-1). Surface waters had slightly higher average (8.19 mg/L) oxygen levels in a range (4.1 to 14.0 mg/L) acceptable for aquatic life support. Dissolved oxygen concentrations in bottom waters were often adequate for aquatic life support (mean = 8.03 mg/L) but concentrations did drop to stressful levels (hypoxia, <4.0 mg/L) during late summer (minimum 3.75 mg/L, Figure A-1). On average bottom waters were slightly lower (paired t-Test, p = 0.0014) in dissolved oxygen (mean difference 0.15 mg/L) than surface waters across all sites.

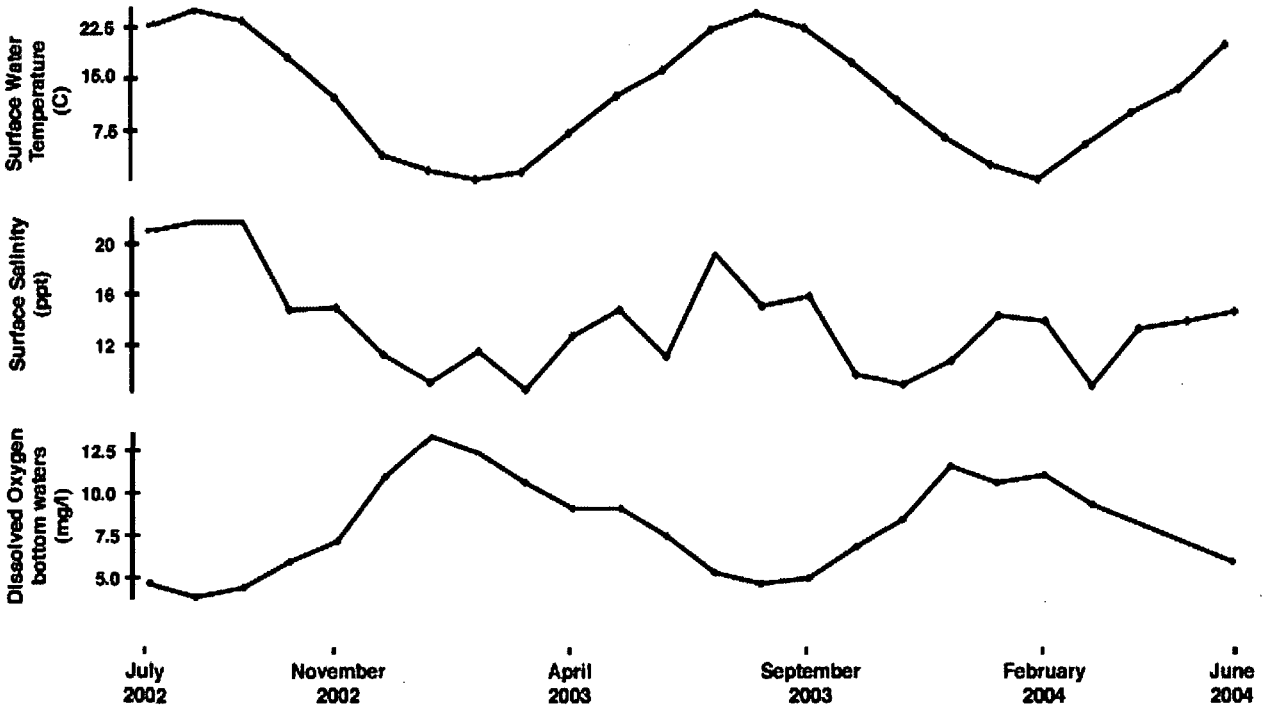

FIGURE A-1
Monthly Mean Surface Water Temperature, Surface Salinity, and Bottom Water Dissolved Oxygen During the Study Period (Bain et al., 2006)

Sediment Quality

Sediment grain size and TOC was analyzed from six locations within the intertidal zone at the Quanta site from both the surface and sub-surface (USEPA 2000). Subsurface samples were collected at locations 2 and 4 at a depth of approximately six to twelve inches after the collocated surface sample was collected. Organic matter content is typically measured as total organic carbon (TOC) and dissolved organic carbon and is an essential component of the carbon cycle. The rate of organic carbon production and decomposition and the resulting microbial biomass indicate the organic character of the sediment. The larger the

carbon or organic content, the greater the growth of microorganisms that can contribute to the depletion of oxygen supplies (USEPA 2001). TOC ranged from 11000 mg/kg at Location 2 to 22000 mg/kg at Location 1.

The grain size distribution was similar at all locations (Table A-1). Silt comprised greater than 71 percent of all samples, ranging from 71.1 to 87.7 percent. Percentages of clay ranged from 10.8 percent to 25.5 percent and sand ranged from 0.4 to 3.5 percent.

Zooplankton

Zooplankton are small animals that live suspended in the water column and drift with the water currents. Zooplankton are primary grazers on phytoplankton and detrital material (i.e. organic debris formed by decomposition of plants and animals) and serve as key prey items for many young-of-year fish as well as fish that are primarily planktivorous throughout their life. Zooplankton include life stages of other organisms such as decapod larvae that spend only part of their life cycle as plankton. Zooplankton in the Hudson River estuary include both freshwater and estuarine species and range in body lengths from microns to millimeters. In saline sections of the Hudson, freshwater forms decline in the oligohaline portions and do not occur in the southern portion of the estuary.

Copepods dominate the zooplankton in the lower Hudson River estuary and New York Bight (Table A-2) (Sage and Herman 1972, USFWS 1997, Levinton and Waldman 2006). Copepods include representatives of three main groups: cyclopoids, calanoids and harpacticoids. A variety of calanoid copepod species are present that vary in salinity preferences and seasonal occurrence. The most common species are *Acartia tonsa, Acartia hudsonica, Eurytemora affinis*, and *Temora longicornis* (NYC EDC). Other calanoid species of *Centropages, Pseudocalanus* and the cyclopoid copepod *Oithona* are also found. Other common zooplankton forms in the Hudson estuary are tintinnids (ciliates), rotifers (wheel-bearing animals) and cladocera (water fleas), as well as a variety of meroplankton (polychaetes, barnacles and crabs). Predatory zooplankton such as ctenophores (*Mnemiopsis leidyi*) and mysid shrimp (*Neomysis americana*), typical of temperate estuaries along the east coast of the United States, also inhabit the lower Hudson estuary.

Zooplankton are typically at low levels during the winter and early spring when low temperatures reduce population growth and high inputs of fresh water result in shorter residence times and increased vertical water movement or advective losses (Levinton and Waldman 2006). Zooplankton become more abundant during spring as water temperature increases.

Benthic Invertebrates

Benthic invertebrates are the most widely used biological assemblage for monitoring due to their susceptibility to degradation by adverse water, sediment, and habitat conditions. Benthic invertebrates are affected by various short-term environmental stressors throughout different life stages, with some stages more sensitive than others to particular stressors. Therefore, benthic invertebrates serve as good indicators of localized environmental conditions.

The substrate type, physical parameters (currents, wave action or disturbance) chemical parameters (DO, salinity and temperature) and life history traits affect the composition and relative abundance of benthic invertebrates. Benthic invertebrates inhabit the sediments and surfaces of submerged objects living on top of the substratum (epifauna) or within the substratum (infauna). Common infaunal macroinvertebrates include aquatic earthworms (oligochaetes), segmented worms (polychaetes), snails (gastropods), bivalves (such as soft shell clams, dwarf surf clam and blue mussel), barnacles, cumaceans, amphipods, isopods, crabs and shrimp (EEA 1988, EA Engineering Science & Technology 1990, NJDEP 1984, Princeton Aqua Science 1985a and 1985b, LMS 1980 and 1984). Common epifauna found on the surface of bottom sediment as well as on natural and artificial hard surfaces include hydrozoans, sea anemones (anthozoans), flatworms, oligochaete worms, polychaetes, bivalves, barnacles, gammaridean and caprellid shrimp, isopods, sea squirts, sand shrimp, hermit crabs, rock crabs, grass shrimp, sand shrimp, blue crabs, mud dog whelks, mud crabs (xanthids), horseshoe crabs and sea slugs (nudibranch) (EEA 1988, EA Engineering Science & Technology 1990, Able et al. 1995, NYCDPR 1994).

The tidal flats adjacent to Quanta OU2 are comprised of unconsolidated sediments of silt and sand and have potential to contain a variety of benthic organisms. A benthic invertebrate survey was conducted in the tidal flats at Quanta to assess community condition using a core sampler (USEPA 2000). Replicate samples were collected from six locations. A total of 14 taxa were collected consisting primarily of nemerteans, oligochaetes, polychaetes, amphipods, isopods and bivalves (Table A-3). Oligochaetes were the dominant taxa, accounting for 82.4 to 94.4 percent of the organisms collected in each sample and 91.4 percent overall. Polychaetous annelids had the highest richness with eight polychaete species sampled. Bivalves and arthropods were second in abundance accounting for 0.07 to 2.6 percent of the total number of individuals. Benthic invertebrate abundances ranged from 153 individuals to 1385 individuals. Benthic invertebrate densities were comparable to those at other locations in the New York Harbor at three of the sample locations, but were an order of magnitude higher at the other three locations (Adams et al. 1998). Species richness at Quanta was comparable to other highly impacted locations in the New York Harbor, such as Newark Bay and Jamaica Bay (Adams et al. 1998).

Benthic communities were assessed in Hudson River Park located on the western waterfront of Manhattan from the Battery Street to 59th Street from June 2002 to June 2004 at eight sampling sites (Bain et al. 2006). This study site is located approximately 5 miles downstream and across the Hudson River from Quanta. Benthic macroinvertebrates were sampled using a Ponar grab (0.053 m2) deployed two times at each site per month. A total of 78,925 benthic organisms representing 145 taxa were collected in the 383 samples. The invertebrate taxa collected include 63 polychaetes, 44 crustaceans, 38 mollusks (17 bivalves and 21 gastropods), 5 maxillopods, 2 pycnogonidans, oligocheates, ostracods and 1 each of several more rare taxa (leech, insect, ascidacean, cnidarian, nemata, porifera, and nemertea). Annelida and mollusca were the most abundant taxa comprising 66 percent and 29 percent of the pooled samples, respectively. The four most common taxa were *Mediomastus spp.* (15 percent), *Mulinia lateralis* (13 percent), Oligochaeta (13 percent), and *Streblospio benedicti* (12 percent) (Table A-4). Overall, 35 percent of the samples were classified as indicating a stressed invertebrate community based on the USEPA Benthic Index of Biotic Integrity. The level of stress detected is similar to the NY-NJ Harbor benthic quality assessments.

NY-NJ Harbor sediment quality assessments were conducted in 1993-1994 and in 1989 (Adams et al. 2003) to define trends in sediment quality and biological health of the Harbor. The New York-New Jersey Harbor included the lower portions of the Hudson, Passaic, Harlem, Hackensack and Raritan rivers, upstream to a near-bottom salinity of 15 ppt, the East River to Long Island Sound, and Lower Harbor to the Atlantic Ocean. The study area was divided into four sub-basins, based on hydrogeography and similar source characteristics: Upper Harbor, Newark Bay, lower Harbor (includes Raritan and Sandy Hook Bays) and Jamaica Bay. Triplicate grabs using a 0.04-m2 stainless steel, Young-modified van Veen grab were collected at 168 stations in 1993-1994 and 112 stations in 1998. Application of the benthic index developed in the baseline investigation (Adams et al. 1998) showed that 31 percent of the Harbor area in 1993-1994 and 53 percent of the Harbor area in 1998 would be considered to have impacted benthic communities.

Shellfish

Shellfish are important food resources for fish and are recreationally and commercially important. Water depth and substrate type strongly influence the distribution of shellfish. Shellfish species found in the lower Hudson River estuary, defined from the Battery at the southern tip of Manhattan north to Stony Point at the northern end of Haverstraw Bay, include northern quahog (*Mercenaria mercenaria*), soft clam (*Mya arenaria*), and eastern oyster (*Crassostrea virginica*) (USFWS 1997). The predominant crustaceans include grass shrimp (*Palaemonetes spp.*), sand shrimp (*Crangon septemspinosa*), and blue crab (*Callinectes sapidus*).

Ichthyoplankton

The lower Hudson River estuary, defined from the Battery at the southern tip of Manhattan north to Stony Point at the northern end of Haverstraw Bay, is ranked among the most productive systems on the northern Atlantic coast for fisheries (USFWS 1997). Many marine spawners use the lower estuary as a nursery area as it provides an ideal habitat for the early critical life stages of these fish species. Marine finfish that use this area include American eel (*Anguilla rostrata*), Atlantic menhaden (*Brevoortia tyrannus*), fourbeard rockling (*Enchelyopus cimbrius*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), northern pipefish (*Syngnathus fuscus*), and longhorn sculpin (*Myoxocephalus octodecemspinosus*). Estuarine fish that spawn in this stretch of the Hudson include winter flounder (*Pleuronectes americanus*), bay anchovy (*Anchoa mitchilli*), hogchoker (*Trinectes maculatus*), and mummichog (*Fundulus heteroclitus*).

Woodhead and McEnroe (1991) studied the available ichthyoplankton (fish eggs and larvae) data from 1972 to 1988 for the Harbor estuary area and characterized the use of the area for spawning and nursery habitat (Table A-5).

Fish

The finfish community in the upper New York Harbor and adjacent water bodies is typical for large coastal estuaries and inshore waterways along the Mid-Atlantic Bight, supporting a variety of estuarine, marine and anadromous fish species (NYCEDC 2004). A study to characterize the fish communities of the New York Harbor area using data collected by

other researchers from 1979 to 1989 was conducted for the Harbor Estuary Program by Woodhead (1991). A total of 101 species were reported in the data sets used; marine species were the most abundant (70 percent) in the entire system, and the greatest diversity occurred in the waters having the highest salinities. Marine species that occurred at all sample sites included bay anchovy (*Anchoa mitchilli*), red hake (*Urophycis chuss*), weakfish (*Cynoscion regalis*), windowpane (*Scophthalmus aquosus*), and winter flounder (*Pleuronectes americanus*).

Migratory fishes, primarily anadromous species, made up about 10 percent of the species and use the Hudson River estuary as an adult migration corridor to the Hudson and other tributaries and as juvenile nursery and overwinter habitat. The principal anadromous fishes included alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), striped bass (*Morone saxatilis*), tomcod (*Microgadus tomcod*), rainbow smelt (*Osmerus mordax*), Atlantic sturgeon (*Acipenser oxyrhynchus*), hickory shad (*Alosa mediocris*), and shortnose sturgeon (*Acipenser brevirostrum*). Catadromous fish include the American eel (*Anguilla rostrata*).

Estuarine species represented only 10 percent of the species sampled but were present in all studies, with the greatest numbers found in the least saline areas. Hogchoker (*Trinectes maculatus*), white perch (*Morone americana*), bay anchovy (*Anchoa mitchilli*), and mummichogs (*Fundulus heteroclitus*) were the most abundant estuarine fish, with pipefish (*Syngnathus fuscus*), threespined stickleback (*Gasterosteus aculeatus*), inland silverside (*Menidia beryllina*), striped killifish (*Fundulus majalis*), white catfish (*Ameiurus catus*), fourspined stickleback (*Apeltes quadracus*), striped mullet (*Mugil cephalus*), and tidewater silverside (*Menidia peninsulae*) represented in most of the areas that were inventoried.

Fish communities were assessed in Hudson River Park located on the western waterfront of Manhattan from the Battery to 59th Street between June 2002 and June 2004 at eight sampling sites (Bain et al. 2006). This study site is located approximately 5 miles downstream and across the Hudson River from Quanta. Fish were captured using a 6-m-wide otter trawl with 5-cm stretch mesh netting and a 0.6-cm stretch mesh cod end liner and collected four times at each site per month. A total of 35,869 fish and 41 species were recorded (Table A-5) with trawl catches ranged from zero to 3,619 fish. Bay anchovy was the most dominant fish species collected comprising 82 percent of the total catch (Table A-6). Bay anchovy, Atlantic herring, striped bass and blueback herring collectively accounted for over 93 percent of the total catch.

Birds

The New York Harbor lies within the Atlantic Flyway, a major migratory pathway for birds and provides important resting and feeding habitats during the spring and fall migrations (USACOE 1999). The area on the Hudson River between Jersey City and Edgewater (river miles 1.5 to 8.8) has significant concentrations of wintering waterfowl, especially canvasback (*Aythya valisneria*), with lesser numbers of scaup (*Athya* spp.), mergansers (*Mergus* spp.), mallard (*Anas platyrhynchos*), and Canada goose (*Branta canadensis*) (USFWS 1997).

Bald eagles have recently been observed overwintering along the lower Hudson reach, with a roost site in the Palisades.

Mammals

Marine mammals use the nearby waters of the New York Bight and occasionally come into NY Harbor. The most commonly observed marine mammal is the harbor seal (*Phoca vitulina*), which winters in the NY Harbor and hauls out onto islands in Jamaica Bay, Sandy Hook, Staten Island, and the Westchester and Connecticut shorelines of the Long Island Sound Narrows (USFWS 1997). Although less frequent, the grey seal (*Halichoerus grypus*) is regularly seen in similar locations. Occasional records of cetaceans (whales, dolphins, and porpoises) in the Harbor are generally of single individuals that are likely unhealthy and/or lost. These marine mammals are unlikely to occur at the Quanta OU2 site due to the highly developed and bulkheaded shoreline and shallow water depth.

Terrestrial mammals are limited by the amount of available habitat. The most abundant small mammals are those that have adapted to human habitation, including meadow vole (*Microtus pennsylvanicus*), cottontail rabbit (*Sylvilagus floridanus*), gray squirrel (*Sciurus carolenensis*), raccoon (*Procyon lotor*), muskrat (*Ondatra zibethicus*), opossum (*Didelphis virginiana*), white-footed mouse (*Peromyscus leucopus*), and eastern chipmunk (*Tamias striatus*) (USFWS 1997). These terrestrial mammals are unlikely to occur at the Quanta OU2 site due to the highly developed and bulkheaded shoreline and lack of preferred habitat.

Amphibians and Reptiles

Four species of marine turtles, all state and federally listed, are found in the New York Bight, including the New York Harbor: loggerhead (*Caretta caretta*), green (*Chelonias mydas*), leatherback (*Dermochelys coriacea*), and Atlantic (=Kemp's) ridley (*Lepidochelys kempii*) (USFWS 1997). Juveniles of Atlantic ridley and larger age classes of the loggerhead often enter the Harbor and bays during summer and fall, and the other sea turtles occasionally enter the higher salinity regions of the New York Harbor. The estuarine northern diamondback terrapin (*Malaclemys t. terrapin*) is found feeding and nesting in salt marshes and adjacent uplands throughout the Harbor from Jamaica Bay up to Piermont Marsh. These four turtle species mostly inhabit Long Island Sound and Peconic and Southern Bays and do not nest or reside in the New York Harbor estuary (NYCEDC 2004). These turtle species migrate into the estuary in June and July and leave in October when colder temperatures force them to migrate south. These turtle species are unlikely to occur at the Quanta site due to the lack of suitable shoreline habitat for feeding and nesting at Quanta OU2. All other amphibians and reptiles in this region are dependent on freshwater wetlands and uplands, and their distribution is very limited to small areas of open space.

Plants (SAV/Emergent Vegetation)

Submerged aquatic vegetation (SAV) comprises vascular plants that live or grow completely underwater, or just up to the water surface. They inhabit shallow areas where light sufficient for photosynthesis can penetrate through the water column, with the highest abundances in water less than three feet deep at low tide (NY/NJ HEP 2000). SAV distribution is influenced by light penetration, salinity, temperature, substrate type, water currents and wave action (Hurley 1990). Submerged aquatic vegetation plays a critical role in many aquatic systems, contributing to primary productivity, nutrient cycling and

sediment dynamics, as well as providing important habitat for fishes and invertebrates. More than twenty aquatic plant species have been recorded in the SAV beds of the Hudson River (Levinton and Waldman 2006). The native water celery (*Vallisneria americana*) is the most predominant species in terms of areal coverage, but the invasive water chestnut (*Trapa natans*) attains a higher standing stock on a smaller area. Other common plants found in shallow water habitats of the Hudson River estuary are Eurasion watermilfoil (*Myriophyllum spicatum*), and redhead grass (*Potamogeton perfoliatus*). No SAV were observed in the tidal flats at Quanta (Harclerode, personal communication, April 13, 2007).

Threatened and Endangered Species

Federally and state-listed species that may inhabit the lower Hudson River Estuary from the Battery at the southern tip of Manhattan north to Stony Point at the northern end of Haverstraw Bay are listed in Table A-7 (USFWS 1997). Letters were submitted to USFWS and NOAA requesting a review of Quanta OU2 for the purposes of identifying if any Federal or State listed rare, endangered, or threatened species, Essential Fish Habitats, warm and cold water fisheries (including unique or critical fisheries), fish passage and spawning areas or outstanding or exceptional resource waters are located within a 1.0-mile radius.

A letter dated January 26, 2006 was received from USFWS regarding the Endangered Species Act. Except for the occasional transient bald eagle (*Haliaeetus leucocephalis*), no federally listed of proposed endangered flora or fauna were identified within the letter as occurring within the vicinity of Quanta OU2. The bald eagle was removed from the federal threatened and endangered species list on August 9, 2007, based on its recovery across the nation and the determination that it no longer needs federal protection.

A letter dated January 26, 2006, was received from NOAA regarding the Endangered Species Act, the Fish and Wildlife Coordination Act and the Magnuson-Stevens Fisher Conservation and Management Act. NOAA indicated that the endangered shortnose sturgeon may be present at Quanta OU2.

The shortnose sturgeon is an anadromous, euryhaline fish. In the Hudson and other large rivers, adult shortnose sturgeon overwinter in deep polyhaline water downstream from the spawning grounds to which they will travel in the following spring when water temperatures reach 8-9°C (Dadswell et al. 1984). Spawning occurs in April and May between Coxsackie and Troy in the Hudson River (Dadswell et al. 1984; Hoff et al. 1988). Adults are thought to move downstream in May and June, after spawning (Hoff et al. 1988).

Eggs of the shortnose sturgeon are demersal and adhesive (Dadswell et al. 1984). Larvae and juveniles are probably benthic, remaining in deep water where currents are strong (Dadswell et al. 1984; Hoff et al. 1988). As a result, little is known about the early life stages. In addition, identification of young specimens (eggs, larvae, and juveniles) is extremely difficult because of overall similarity to young Atlantic sturgeon (Hoff et al. 1988). Some workers (i.e., Hoff et al. 1988) believe that the larvae disperse downstream during summer, whereas others (i.e., Dadswell et al. 1984) believe that young shortnose sturgeon remain above the salt front until they reach 45 cm total length (TL). Upon attaining adult size (45-50 cm TL), shortnose sturgeon move downriver in fall, and back upriver in spring (Dadswell et al., 1984).

While the shortnose sturgeon can be found throughout the Hudson River system, eggs, larvae and juveniles will unlikely inhabit the waters in the vicinity of Quanta OU2 as spawning occurs in freshwater, over 100 miles upstream. Adults are only expected to use the portion of the Hudson River in the OU2 area while migrating to or from their preferred spawning, nursery or overwintering area upriver. It is highly unlikely that adult shortnose sturgeon would utilize the shallow flats during migration as they prefer deep water with high velocity currents.

Essential Fish Habitat (EFH)

A letter dated January 26, 2006 was received from NOAA regarding the Endangered Species Act, the Fish and Wildlife Coordination Act and the Magnuson-Stevens Fisher Conservation and Management Act. The project area was designated as Essential Fish Habitat (EFH) for one or more species. The Guide to Essential Fish Habitat Designations in the Northeastern United States (http://www.nero.noaa.gov/hcd/webintro.html) was consulted to determine the species and life stages of fish, shellfish, and mollusks for which EFH has been designated in a selected 10′ x 10′ square of latitude and longitude along the coast. The selected 10′ x 10′ square coordinates (Table A-8) comprise the Hudson River and Bay from Guttenberg, N.J., south to Jersey City, N.J., including the Global Marine Terminal and the Military Ocean Terminal, Bayonne, N.J., Hoboken, N.J., Weehawken, N.J., Union City, N.J., Ellis Island, Liberty Island, Governors Island, the tip of Red Hook Pt. on the west tip of Brooklyn, NY, and Newark Bay. Species for which EFH has been designated is presented in Table A-9. Quanta OU2 is included within these 10′ by 10′ square coordinates.

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TABLE A-1

Grain Size and Total Organic Carbon Detected in Sediment at Quanta Site (USEPA 2000)

Parameter	Location 1	Location 2	Location 2 Sub	Location 3	Location 4	Location 4 Sub	Location 5	Location 6
TOC (mg/kg)	22000	11000	15000	17000	16000	15000	16000	14000
Percent sand	3.46	1.05	1.03	1.79	0.6	0.76	0.36	0.41
Percent silt	71.06	78.93	87.72	87.39	75.24	83.71	82.49	75.77
Percent clay	25.48	20.02	11.25	10.82	24.16	15.53	17.15	23.82

TABLE A-2

Salinity Classification and Location of Common Copepod Species Likely to Occur in the Lower Hudson River Estuary (adapted from Malone [1977])

Species	Salinity Classification	Areas Found
Eurytemora affinis	e	E, IB
Eurytemora americana	e	E, BIS, IB,
Eurytemora herdmani	e	E, BIS
Acartia clausi	e-m	E, BIS, IB, OB
Acartia tonsa	e-m	E, BIS, IB, OB
Pseudodiaptomus coronatus	e-m	E
Oithona brevicornis	e-m	E, BIS, IB
Oithona similis	e-m	E, BIS, IB, OB
Tortanus discaudatus	e-m	E, BIS, IB, OB
Paracalanus crassiostris	e-m	E, BIS, IB, OB
Pseudocalanus minutus	eu-m	E, BIS, IB, OB
Labidocera aestiva	eu-m	E, BIS, IB, OB
Temora longicornis	eu-m	E, BIS, IB, OB
Centropages hamatus	eu-m	E, BIS, IB, OB
Centropages typicus	s-m	E, BIS, IB, OB
Calanus finmarchicus	s-m	E, BIS, IB, OB

e = estuarine
e-m = estuarine - marine
eu-m = euryhaline - marine
s-m = stenohaline - marine

E = estuary
BIS = Block Island Sound
IB = inner Bight
OB = outer Bight

TABLE A-3

Benthic Invertebrate Species Composition and Abundance at Quanta

Phylum	Class	Subclass	Order	Family	Genus species	Locations						Total	Percent Composition
						1	2	3	4	5	6		
Nematoda						2	1	1	0	0	0	4	0.1
Nemertinea						0	0	0	3	13	2	18	0.44
Annelida	Oligochaeta					152	1,162	786	1,307	249	126	3,782	91.42
	Polychaeta		Ampharetidae		*Asabellides oculata*	9	0	4	4	0	1	18	0.44
			Capitellidae			0	18	0	6	2	7	33	0.8
			Nereidae		*Neanthes succinea*	0	3	1	1	13	6	24	0.58
			Orbinidae		*Leitoscoloplos sp.*	0	2	0	2	1	0	5	0.12
			Phyllodocidae		*Eteone heteropoda*	1	14	10	23	6	2	56	1.35
			Spionidae		*Polydora ligni*	1	0	0	0	0	0	1	0.02
					Scolecolepides viridis	0	1	0	0	4	0	5	0.12
					Streblospio benedicti	2	52	49	34	4	1	142	3.43
Arthropoda		Copepoda				7	2	3	3	4	2	21	0.51
			Amphipoda	Gammaridae		0	0	0	1	1	0	2	0.05
			Isopoda		*Cyathura polita*	0	0	0	0	4	4	8	0.19
Molluska	Bivalvia			Tellinidae	*Macoma balthica*	1	0	2	0	4	3	10	0.24
					Telina agilis	1	1	0	4	1	1	8	0.19
Total						**176**	**1256**	**856**	**1388**	**306**	**155**	**4137**	**100**

Source: USEPA 2000

TABLE A-4

Common Benthic Invertebrate Taxa and Relative Abundance at Hudson River Park, approximately 5 miles downstream from Quanta OU2

Taxa	Phylum	Class	Order	Family	No. Recorded	Relative Abundance
Mediomastus spp.	Annelida	Polychaeta	Capitellida	Capitellidae	11,833	0.15
Mulinia lateralis	Mollusca	Bivalvia	Veneroida	Mactridae	10,488	0.13
Oligochaeta	Annelida	Clitellata			10,077	0.13
Streblospio benedicti	Annelida	Polychaeta	Spionida	Spionidae	9,129	0.12
Acteocina canaliculata	Mollusca	Gastropoda	Cephalaspidea	Cylichnidae	5,785	0.07
Leitoscoloplos spp.	Annelida	Polychaeta	Orbiniida	Orbiniidae	5,815	0.07
Capitellidae	Annelida	Polychaeta	Capitellida		2,494	0.03
Rictaxis punctostriatus	Mollusca	Gastropoda	Cephalaspidea	Acteonidae	2,255	0.03
Heteromastus sp.	Annelida	Polychaeta	Capitellida	Capitellidae	2,240	0.03
Spio setosa	Annelida	Polychaeta	Canalipalpata	Spionidae	2,194	0.03
Tellina agilis	Mollusca	Bivalvia	Veneroida	Tellinidae	1,570	0.02
Tharyx spp.	Annelida	Polychaeta	Spionida	Cirratulidae	1,491	0.02
Leucon americanus	Arthropoda	Malacostraca	Cumacea	Leuconidae	1,399	0.02
Ostracoda	Arthropoda				1,205	0.02
Pectinaria gouldii	Annelida	Polychaeta	Terebellida	Pectinariidae	999	0.01
Eteone sp.	Annelida	Polychaeta	Aciculata	Phyllodocidae	948	0.01
Orbiniidae	Annelida	Polychaeta	Ariciida		910	0.01
Hydrobia totteni	Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	872	0.01
Polydora ligni	Annelida	Polychaeta	Canalipalpata	Spionidae	865	0.01
Nassarius obsoletus	Mollusca	Gastropoda	Neogastropoda	Nassariidae	832	0.01
Leitoscoloplos fragilis	Annelida	Polychaeta	Ariciida	Orbiniidae	746	0.01
Spio sp.	Annelida	Polychaeta	Canal ipalpata	Spionidae	372	0.01

TABLE A-5
Use of the Harbor Estuary for Spawning and Nursery Area

Type	Common Name	Species Name	Spawning Coldwater	Spawning Warmwater	Use As Nursery Area
Marine	American sandlance		X		X
	bluefish				X
	butterfish	*Peprilus triacanthus*			X
	cunner	*Tautogolabrus adspersus*		X	X
	summer flounder				X
	four-beard rockling	*Enchelyopus cimbrius*	X		X
	four-spot flounder	*Paralichthys oblongus*			X
	grubby sculpin	*Myoxcephalus aenaeus*	X		X
	lookdown	*Selene vomer*			X
	lined seahorse	*Hippocampus erectus*		X	
	naked goby	*Gobiosoma bosci*		X	
	northern puffer	*Sphoeroides maculatus*		X	X
	northern searobin				X
	red hake				X
	rock gunnel			X	
	round herring				X
	seaboard goby	*Gobiosoma ginsburgi*			X
	scup				X
	silver hake	*Merluccius bilinearis*			X
	smallmouth flounder	*Etropus microstomus*			X
	spotted hake				X
	striped searobin	*Prionotus evolans*			X
	tautog			X	X
	weakfish				X
	windowpane	*Scophthalmus aquosus*		X	
	winter flounder		X		X
Migratory	alewife			X	X
	American eel				X
	American shad			X	X
	Atlantic menhaden			X	X
	bay anchovy			X	X
	blueback herring			X	X
	striped bass				X
	tomcod		X		X
Estuarine	Atlantic silversides			X	X
	banded killifish			X	X
	hogchoker			X	X
	inland silverside			X	X
	mummichog			X	X
	northern pipefish			X	X
	striped killifish				X
	3-spine stickleback			X	X
	4-spine stickleback			X	X
	white perch			X	X

Notes:
Warmwater = Waters exceeding 24°C (Journal of Ichthyology)
Coldwater = Waters of 20°C or less (Journal of Ichthyology)
Source: Woodhead and McEnroe (1991)

TABLE A-6

Fish Species Composition and Abundance at Hudson River Park, approximately 5 miles downstream from Quanta OU2 (from Bain et.al. 2006)

Common Name	Species Name	Number of Individuals	Percent Composition
Bay anchovy	*Anchoa mitchilli*	29,314	81.73
Atlantic herring	*Clupea harengus*	1,903	5.31
Striped bass	*Morone saxatilis*	1,328	3.7
Blueback herring	*Alosa aestivalis*	850	2.37
Alewife	*Alosa pseudoharengus*	704	1.96
Atlantic tomcod	*Microgadus microgadus*	397	1.11
Striped anchovy	*Anchoa hepsetus*	186	0.52
American shad	*Alosa sapidissima*	166	0.46
Butterfish	*Peprilus triacanthus*	159	0.44
Shad, unidentified	*Alosa*	140	0.39
Weakfish	*Cynoscion regalis*	135	0.38
Atlantic menhaden	*Brevoorta tyrannus*	94	0.26
Winter flounder	*Pseudopleuronectes americanus*	82	0.23
Bluefish	*Pomatomus saltatrix*	82	0.23
Atlantic croaker	*Micropogonias undulatus*	68	0.19
White perch	*Morone americana*	47	0.13
Northern pipefish	*Syngnathus fuscus*	37	0.1
Spotted hake	*Urophycis regia*	31	0.09
Gizzard shad	*Dorosoma cepedianum*	21	0.06
Summer flounder	*Paralichthys dentatus*	20	0.06
Northern searobin	*Prionotus carolinus*	13	0.04
Hickory shad	*Alosa mediocris*	12	0.03
Scup	*Stenotomus chrysops*	11	0.03
Hogchoker	*Trinectes maculatus*	8	0.02
Silver hake	*Merluccius bilinearis*	8	0.02
American eel	*Anguilla rostrata*	6	0.02
Atlantic silverside	*Menidia menidia*	6	0.02
Seaboard goby	*Gobiosoma ginsburgi*	6	0.02
Grubby	*Myoxocephalus aenaeus*	4	0.01
Gulf Stream flounder	*Citharichthys arctifrons*	4	0.01
Red hake	*Urophycis chuss*	4	0.01
Lookdown	*Selene vomer*	3	0.01
Spot	*Leiostomus xanthurus*	3	0.01
Windowpane	*Scophthalmus aquosus*	3	0.01
Striped searobin	*Prionotus evolans*	3	0.01
Cunner	*Tautogolabrus adspersus*	2	0.01
Lined seahorse	*Hippocampus erectus*	2	0.01
Northern stargazer	*Astroscopus guttatus*	2	0.01
Feather blenny	*Hypsoblennius hentzi*	1	0
Gobies, unidentified	*Gobiidae, Gobiosoma*	1	0
Goosefish	*Lophius americanus*	1	0
Northern kingfish	*Menticirrhus saxatilis*	1	0
Rock sea bass	*Centropristis philadelphica*	1	0
Total		**35,869**	**100**

TABLE A-7

Potential Threatened and Endangered Species in the Lower Hudson River Estuary

Common Name	Species Name	FE	FT	FC	SE NJ	ST NJ	ST NY	SC NY
Peregrine falcon	*Falco peregrinus*	X						
Bald eagle	*Haliaeetus leucocephalus*		X					
Northern diamondback terrapin	*Malaclemys t. terrapin*			X				
Shortnose sturgeon	*Acipenser brevirostrum*	X						
Mud sunfish	*Acantharchus pomotis*				X			
Osprey	*Pandion haliatus*					X	X	
Banded sunfish	*Enneacanthus obesus*							X
Cylindrical-headed bulrush	*Scirpus novae-angliae*				X			

Notes:

Species of special concern listed here include former Category 2 candidates.

FE = Federal endangered
FT = Federal threatened
FS = Federal species of concern
FC = Federal candidate

SE = State endangered
ST = State threatened
SC = State species of concern
NJ = New Jersey
NY = New York

TABLE A-8
10' x 10' Square Coordinates

Boundary	North	East	South	West
Coordinate	40° 50.0' N	74° 00.0' W	40° 40.0' N	74° 10.0' W

Appendix B
Refined Ecological Risk Screening—OU2, Quanta Resources

Refined Ecological Risk Screening—OU2, Quanta Resources

Introduction

This appendix presents an ecological risk screening of the surface sediment sample data collected during the OU2 RI. The purpose of this screening is to identify data gaps in the evaluation of ecological risk at OU2 and further focus to the BERA investigation. The methods and approaches used in this refined ecological risk screening were developed from USEPA ERA guidance (USEPA, 1997) and incorporate elements of a screening-level ecological risk assessment (SLERA) (Steps 1 and 2) and the first part of Step 3 of the 8-step ERA process (USEPA, 1997).

Effects Evaluation

The purpose of the screening-level effect evaluation is to establish chemical exposure levels (toxic effects/toxicity reference values) that represent conservative thresholds for adverse ecological effects.

Sediment Direct Exposure Toxic Effects Values

Sediment direct exposure marine toxic effects values for benthic invertebrates were based on the following sources:

- New Jersey DEP Guidance for Sediment Quality Evaluations
- USEPA Region III BTAG Marine Sediment Screening Benchmarks

The toxic effects values used in this evaluation are listed in Table B-1.

An additional analysis was completed to determine the potential for risk from PAHs. The ESBTU protective of benthic organisms (invertebrates and fish) were calculated for each sample location (USEPA, 2003). The ESBTU was calculated using dry weight concentrations of individuals PAHs, site-specific levels of organic carbon (for this analysis, the TOC at each sample location was used), and an adjustment factor to account for the toxicological contribution of unmeasured PAHs. An ESBTU accounts for the toxicological contribution of 34 PAHs and is calculated based upon the direct measure of these compounds in sediments. During the RI (CH2M HILL, 2005), only a subset (30) of the sediment samples collected were analyzed for 34 PAHs. The remaining sediment samples were analyzed for 13 PAHs. In order to allow the full complement of sediment data to be used in this evaluation, a site-specific adjustment factor (1.55) was developed using the data from the samples on which all 34 PAHs were analyzed. This factor was then used to adjust the data for samples on which only 13 PAHs were analyzed. Sediments containing ESBTUs less than 1.0 are acceptable for the protection of benthic organisms, while an ESTBU greater than 1.0 indicates that sensitive benthic organisms may be unacceptably affected.

Ingestion Toxicity Reference Values

Ingestion toxicity reference values were derived for dietary exposures to the bioaccumulative chemicals at the site (Table B-2). Bioaccumulative chemicals were identified based on USEPA (2000). Among PAHs, only 2-methylnapthalene and naphthalene are not considered bioaccumulative and were not evaluated individually, although their contribution to the total PAH levels was included. Growth and reproduction were emphasized for the assessment endpoints since they are the most relevant, ecologically, to maintaining viable populations and because they are generally the most studied chronic toxicological endpoints for ecological receptors.

For wildlife exposure, toxicological information from the literature for wildlife species most closely related to the receptor species was used, when available, but was supplemented by laboratory studies of non-wildlife species where necessary. The ingestion toxicity reference values are expressed as milligrams of the chemical per kilogram body weight of the receptor per day (mg/kg-BW/day). For arsenic, the toxicity reference value is the value used in the derivation of the Eco-SSL for avian receptors (USEPA 2005). For PAHs, an Eco-SSL for avian receptors was not identified (USEPA 2007), so the value in Rigdon and Neal (1963) was used, which is a subchronic No Observed Adverse Effect Levels (NOAEL) for growth effects in chicken exposed to benzo(a)pyrene. An uncertainty factor of 10 was applied to convert from subchronic to a chronic duration exposure. A Lowest Observed Adverse Effect Level (LOAEL) was not derived by Rigdon and Neal (1963), so a value of 10 times the NOAEL was used.

Exposure Estimate

95UCL concentrations in sediment were used to estimate potential chemical exposures to ecological receptors. For conservatism, one-half the detection limits for chemicals that were analyzed for but not detected were also compared to medium-specific toxic effects values and used for food web exposure modeling. This was done to evaluate whether detection limits were, in general, low enough to support the assessment. For samples with duplicate analyses, the higher of the two concentrations was used in the screening (i.e., when both values were detects or both values were non-detects). In cases where one result was a detect and the other a non-detect, the detected value was used in the assessment.

For mobile ecological receptors, 95UCL chemical concentrations provide a better estimate of the likely level of chemical exposure because each of the receptors would be expected to forage in several different areas of the site, and in many cases, at off-site locations. 95UCL concentrations also provided a better estimate of the exposures experienced at the population level. The 95UCL concentrations are appropriate for evaluating impacts to populations of sediment invertebrates because, while some of these receptors are relatively immobile and individuals are more likely to be impacted by locations of maximum concentration, evaluation of the 95UCL exposure case is more instructive with regard to the level of impact that might be expected at the population level.

Exposures for avian receptor species via the food web were determined by estimating the chemical-specific concentrations in each dietary component using uptake and food web models. Avian receptor exposures to chemicals in sediment were determined by estimating

the concentration of each chemical in each relevant dietary component. Incidental ingestion of sediment was included when calculating the total exposure, where appropriate. Body weights, ingestion rates, and dietary composition for each receptor are presented in Table B-3.

Dietary items for which tissue concentrations were modeled include aquatic plants, aquatic invertebrates, and fish. The methodologies used for these tissue calculations are outlined in the following subsection.

Exposure Point Concentrations

95UCL sediment concentrations were used as exposure point concentrations for the avian food web modeling exposure estimation. Exposure point concentrations for aquatic prey items (aquatic plants, aquatic invertebrates, and fish) were estimated using bioaccumulation models and measured sediment concentrations. The models used to derive these estimates are described below.

Aquatic Plants. Tissue concentrations in aquatic plants were estimated by multiplying the 95UCL sediment concentration for each chemical by chemical-specific biota-sediment accumulation factors (BAFs) obtained from the literature. The BAF values were based on root uptake from sediment and on the ratio between dry-weight sediment and dry-weight plant tissue. For PAHs, sediment-to-plant BAFs were estimated using the BAFs in USEPA (2005) for terrestrial plants and soil. The sediment-to-plant BAFs used in the ERA are provided in Table B-4.

Aquatic Invertebrates. Tissue concentrations in aquatic invertebrates were estimated by multiplying the sediment concentration for each chemical by chemical-specific sediment-to-invertebrate BAFs obtained from the literature. The BSAF values used are based on the ratio between dry-weight sediment and dry-weight invertebrate tissue. The sediment-to-invertebrate BAFs used in the screening portion of the ERA are shown in Table B-4.

Fish. For arsenic, tissue concentrations in whole-body fish were estimated by multiplying the 95UCL sediment concentration by a chemical-specific sediment-to-fish BAF obtained from the literature. For PAHs, BAFs were not available in the literature so a BAF of 1.0 was assumed.

Dietary Intakes

Dietary intakes for each avian receptor species were calculated using the following formula (modified from USEPA [1993]):

$$DI_x = \frac{[[\sum_i (FIR)(FC_{xi})(PDF_i)] + [(FIR)(SC_x)(PDS)]]}{BW}$$

where:
- DI_x = Dietary intake for chemical x (mg chemical/kg body weight/day)
- FIR = Food ingestion rate (kg/day, dry-weight)
- FC_{xi} = Concentration of chemical x in food item i (mg/kg, dry weight)
- PDF_i = Proportion of diet composed of food item i (dry weight basis)
- SC_x = Concentration of chemical x in sediment (mg/kg, dry weight)

PDS = Proportion of diet composed of sediment (dry weight basis)
BW = Body weight (kg, wet weight)

Receptor-specific values used as inputs to this equation were provided in Table B-3. For conservatism, the model assumes that chemicals are 100 percent bioavailable to the receptor and that each receptor spends 100 percent of its time within the boundaries of the site (i.e., an Area Use Factor was not applied).

Risk Calculation

In the risk calculation, the exposure concentrations are compared with their corresponding toxic effects/toxicity reference values to derive risk estimates. The outcome of this step is a list of COPCs for pathway-receptor combinations that require further evaluation

COPCs were selected using the hazard quotient (HQ) method. HQs are calculated by dividing the chemical concentration by the corresponding specific toxic effects value or by dividing the exposure dose by the corresponding toxicity reference value. Chemicals with HQs greater than one were considered COPCs. Chemicals with HQs less than or equal to one were eliminated from further consideration.

Sediment. The risk calculations for detected chemicals in surface sediment are presented in Table B-5. The 95UCL concentrations of all chemicals exceeded toxic effects values and are considered COPCs for direct contact receptors.

Calculations for PAHs based upon the ESBTU approach for benthic invertebrates are presented in Table B-6.

Results of the screening of PAHs with the ESBTU (Table B-6) and arsenic with the literature toxic effects value (Table B-5) are shown in Figures 4-1 and 4-2, respectively.

Ingestion Exposure. The risk calculations for food web exposures for OU2 are presented in Tables B-7 through B-11. Except for total PAHs and the great blue heron, the estimated dose for each chemical evaluated did not exceed NOAEL-based ingestion toxicity reference values for any receptor. The hazard quotient for the total PAHs and the great blue heron slightly exceeded the NOAEL-based toxicity reference value but not the LOAEL-based toxicity reference value or the MATC (the median of the NOAEL and LOAEL).

Risk Conclusions

The results of the risk calculations for each assessment endpoint and representative receptor are presented below:

Benthic Invertebrate Community

Arsenic and PAHs in OU2 surface sediments pose a potential risk to the benthic invertebrate community and these COPCs will be investigated further in the BERA.

Shorebirds (Semipalmated Sandpiper)

Arsenic and PAHs do not pose a potential risk to shorebirds, as evaluated with the semipalmated sandpiper, and no further investigation is necessary.

Herbivorous Aquatic Birds (Canada Goose)

Arsenic and PAHs do not pose a potential risk to omnivorous aquatic birds, as represented by Canada goose, and no further investigation is necessary.

Piscivorous Aquatic Birds (Great Blue Heron)

Arsenic and individual PAHs do not represent a potential risk to piscivorous aquatic birds, as represented by great blue heron. No further evaluation of these chemicals is therefore required for this receptor. Total PAHs indicated a very low risk (HQ of 3) when compared to the highly conservative NOAEL. The LOAEL and the MATC, however, were not exceeded, and risks to piscivorous aquatic bird populations (the assessment endpoint evaluated) are considered unlikely. It should additionally be noted that risks to the great blue heron were based primarily on fish ingestion, which included a default BAF of 1.0 for total PAH bioaccumulation into fish. Although limited data are available (USACE 2008), actual bioaccumulation into fish is most likely to be less, thereby reducing the risk estimates.

Omnivorous Aquatic Birds (Black Duck)

Arsenic and PAHs do not pose a potential risk to herbivorous aquatic birds, as represented by black duck, and no further investigation is necessary.

Omnivorous Mammals (Raccoon)

Arsenic and PAHs do not pose a potential risk to omnivorous mammals, as represented by the raccoon, and no further investigation is necessary.

Uncertainty

The primary uncertainties associated with the estimate of risk for the selected assessment endpoints and the additional data that will be collected to reduce these uncertainties are discussed in Sections 4 and 5 of this document.

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TABLE B-1
Sediment Toxic Effects Values

Chemical	Toxic Effects Value (MG/KG)	Source
Inorganics		
Arsenic	8.2	NJDEP
Semivolatile Organics		
2-Methylnaphthalene	0.07	NJDEP
Acenaphthene	0.016	NJDEP
Acenaphthylene	0.044	NJDEP
Anthracene	0.085	NJDEP
Benzo(a)anthracene	0.261	NJDEP
Benzo(a)pyrene	0.43	NJDEP
Benzo(b)fluoranthene	3.2	EPA Region III
Benzo(g,h,i)perylene	0.17	NJDEP
Benzo(k)fluoranthene	0.24	NJDEP
Chrysene	0.38	NJDEP
Dibenz(a,h)anthracene	0.06	NJDEP
Fluoranthene	0.6	NJDEP
Fluorene	0.019	NJDEP
Indeno(1,2,3-cd)pyrene	0.2	NJDEP
Pentachlorophenol	0.16	NJDEP
Phenanthrene	0.24	NJDEP
Pyrene	0.67	NJDEP
Total PAHs	4	NJDEP

TABLE B-2
Bird Ingestion Toxicity Reference Values

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	Reference/Description
Inorganics								
Arsenic	Chicken	1.6	19 days	Oral in diet	Reproduction	2.24	NA	Holcman and Stibilj, 1997; Value recommended by Eco-SSL (USEPA 2005)
Semivolatile Organic Compounds								
Acenaphthene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Acenaphthylene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Anthracene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Benzo(a)anthracene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Benzo(a)pyrene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Rigdon and Neal 1963; Subchronic NOAEL adjusted with uncertainty factors (10X) for conversion to chronic duration and LOAEL; Eco-SSL not available
Benzo(b)fluoranthene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Benzo(g,h,i)perylene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Benzo(k)fluoranthene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Chrysene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Dibenz(a,h)anthracene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Fluoranthene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Fluorene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Indeno(1,2,3-cd)pyrene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Phenanthrene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Pyrene	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene
Total PAHs	Chicken	1.50	35 days	Oral in diet	Reproduction	71	7.10	Value for benzo(a)pyrene

TABLE B-3
Exposure Parameters for Upper Trophic Level Ecological Receptors

Receptor	Average Body Weight (kg)		Water Ingestion Rate (L/day)		Food Ingestion Rate (kg/day - dry)		Dietary Composition (percent)				Sediment Ingestion (percent)	
	Value	Reference	Value	Reference	Value	Reference	Fish	Aquatic Plants	Benthic Invert.	Reference	Value	Reference
Raccoon	5.94	Silva and Downing 1995	0.4921	allometric equation	0.1031	Conover 1989	7.0	40	43.6	USEPA 1993	9.4	Beyer et al. 1994
Canada goose	3.56	Dunning 1993	0.1382	allometric equation	0.0984	USEPA 1993	0	91.8	0	USEPA 1993	8.2	Beyer et al. 1994
Great blue heron	2.23	Quinney 1982	0.1010	allometric equation	0.3931	allometric equation	100	0	0	USEPA 1993; Quinney and Smith 1980	0	Sample and Suter 1994
Black Duck	1.20	Longcore et al. 2000	0.0668	allometric equation	0.0657	allometric equation	0	4.7	92	Longcore et al. 2000	3.3	Beyer et al. 1994; Value for mallard
Semipalmated sandpiper	0.0252	Gratto-Teveor 1992	0.0059	allometric equation	0.0055	allometric equation	0	0	70	Gratto-Teveor, 1992	30	Beyer et al. 1994

TABLE B-4
Sediment Bioaccumulation Factors

Chemical	Sediment-Plant BCF (dry weight)		Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference	Value	Reference
Inorganics						
Arsenic	0.038	USEPA 2005	0.127	Median; Bechtel Jacobs 1998b	0.126	Pascoe et al. 1996
Semivolatile Organic Compounds						
Acenaphthene	Regression equation	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Acenaphthylene	Regression equation	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Anthracene	Regression equation	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Benzo(a)anthracene	Regression equation	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Benzo(a)pyrene	Regression equation	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Benzo(b)fluoranthene	0.31	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Benzo(g,h,i)perylene	Regression equation	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Benzo(k)fluoranthene	Regression equation	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Chrysene	Regression equation	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs

TABLE B-4
Sediment Bioaccumulation Factors

Chemical	Sediment-Plant BCF (dry weight)		Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference	Value	Reference
Dibenz(a,h)anthracene	0.13	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Fluoranthene	0.50	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Fluorene	Regression equation	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Indeno(1,2,3-cd)pyrene	0.11	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Phenanthrene	Regression equation	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Pyrene	0.72	USEPA 2005; Value for soil and terrestrial plants	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs
Total PAHs	Regression equation	Value for benzo(a)pyrene	0.301	USACE 2008; 95UCL for marine worms, all PAHs	0.472	USACE 2008; Grand Mean for all species (fish, inverts, plants), FW and Marine, all PAHs

TABLE B-5
Screening Statistics- Sediment

Chemical	Range of Non-Detect Values	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	95UCL Concentration	Toxic Effects Value	95UCL Hazard Quotient	COPC
Inorganics (MG/KG)								
Arsenic	-- - --	73 / 73	92.0	SD-B-10-0-0.5	23.2	8.20	2.8	YES
Semivolatile Organic Compounds (MG/KG)								
2-Methylnaphthalene	0.021 - 0.030	14 / 73	70.7	SD-A-04-0-0.5	5.43	0.07	78	YES
Acenaphthene	6.00E-04 - 7.00E-04	67 / 73	62.1	SD-A-04-0-0.5	9.91	0.02	619	YES
Acenaphthylene	-- - --	73 / 73	7.28	SD-A-07-0-0.5	1.31	0.04	30	YES
Anthracene	-- - --	73 / 73	41.7	SD-A-04-0-0.5	4.80	0.09	56	YES
Benzo(a)anthracene	-- - --	73 / 73	36.4	SD-A-04-0-0.5	6.72	0.26	26	YES
Benzo(a)pyrene	-- - --	73 / 73	31.1	SD-A-04-0-0.5	6.01	0.43	14	YES
Benzo(b)fluoranthene	-- - --	73 / 73	32.1	SD-A-04-0-0.5	5.74	3.20	1.8	YES
Benzo(g,h,i)perylene	-- - --	73 / 73	15.4	SD-A-07-0-0.5	2.94	0.17	17	YES
Benzo(k)fluoranthene	-- - --	73 / 73	19.6	SD-A-04-0-0.5	4.38	0.24	18	YES
Chrysene	-- - --	73 / 73	32.0	SD-A-04-0-0.5	6.00	0.38	16	YES
Dibenz(a,h)anthracene	-- - --	73 / 73	5.28	SD-A-07-0-0.5	1.11	0.06	18	YES
Fluoranthene	-- - --	73 / 73	92.5	SD-A-04-0-0.5	16.86	0.60	28	YES
Fluorene	8.00E-04 - 8.00E-04	72 / 73	58.3	SD-A-04-0-0.5	19.61	0.02	1032	YES
Indeno(1,2,3-cd)pyrene	-- - --	73 / 73	15.2	SD-A-04-0-0.5	2.96	0.20	15	YES
Naphthalene	4.05E-04 - 5.00E-04	62 / 73	196	SD-A-04-0-0.5	2.83	0.16	18	YES
Phenanthrene	-- - --	73 / 73	171	SD-A-04-0-0.5	18.42	0.24	77	YES
Pyrene	-- - --	73 / 73	86.3	SD-A-04-0-0.5	13.78	0.67	21	YES
Total HMW PAHs	-- - --	73 / 73	365	SD-A-04-0-0.5	65.8	0.19	346	YES
Total LMW PAHs	-- - --	73 / 73	606	SD-A-04-0-0.5	65.8	0.08	865	YES
Total PAHs	-- - --	73 / 73	972	SD-A-04-0-0.5	123.5	4	31	YES

Note
Reporting limits are presented for non-detected chemicals only

NSV - No Screening Value
1 - Shaded cells indicate hazard quotient based on reporting limits

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Value

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	$C_{OC, PAHi, Maxi}$ (ug/g_{OC})	SD-A-01 (TOC = 2.76%; f_{OC} = 0.0276)			SD-A-02 (TOC = 2.76%; f_{OC} = 0.0276)			SD-A-03 (TOC = 2.76%; f_{OC} = 0.0276)			SD-A-04 (TOC = 5.18%; f_{OC} = 0.0518)			SD-A-06 (TOC = 4.08%; f_{OC} = 0.0408)		
			Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	All Species $ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	61,700	0.087	3.1	0.00816	0.189	6.85	0.0178	1.96	71.0	0.184	196	3,784	9.83	0.842	20.6	0.0536
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	24,000	0.360	13.0	0.0289	0.445	16.1	0.0357	0.843	30.5	0.068	6.36	123	0.272	3.51	86.0	0.190
Acenaphthene	491	33,400	0.235	8.5	0.0173	0.697	25.3	0.0514	5.53	200	0.408	62.1	1199	2.44	2.50	61.3	0.125
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	26,000	0.208	7.5	0.0140	0.758	27.5	0.0510	3.85	139	0.259	58.3	1,125	2.09	1.79	43.9	0.0815
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	1,300	0.632	22.9	0.0385	1.23	44.6	0.0750	5.83	211	0.356	41.7	805	1.36	3.31	81.1	0.137
Phenanthrene	596	34,300	1.14	41.3	0.0693	3.95	143	0.240	25.0	906	1.52	171	3,301	5.54	7.16	175	0.294
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	9,090	3.86	140	0.201	5.58	202	0.290	32.3	1170	1.68	86.3	1,666	2.39	30.3	743	1.07
Fluoranthene	707	23,870	4.54	164	0.233	5.48	199	0.281	30.7	1112	1.57	92.5	1,786	2.53	34.7	850	1.20
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	4,153	2.26	81.9	0.0974	3.16	114	0.136	17.1	620	0.737	36.4	703	0.836	13.8	338	0.402
Chrysene	844	826	2.13	77.2	0.0914	3.17	115	0.136	17.7	641	0.760	32.0	618	0.732	13.1	321	0.380
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	3,840	2.30	83.3	0.0864	3.16	114	0.119	16.0	580	0.601	31.1	600	0.622	16.8	412	0.427
Perylene	967	431	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	4,300	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	2,169	2.23	80.8	0.0825	3.05	111	0.113	12.6	457	0.466	32.1	620	0.633	14.6	358	0.366
Benzo(k)fluoranthene	981	1,220	1.79	64.9	0.0661	2.69	97.5	0.0994	16.0	580	0.591	19.6	378	0.386	14.9	365	0.372
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	648	0.747	27.1	0.0247	1.19	43.1	0.0394	7.00	254	0.232	15.1	292	0.266	6.89	169	0.154
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	--	0.792	28.7	0.0257	1.32	47.8	0.0429	7.13	258	0.232	15.2	293	0.263	6.90	169	0.152
Dibenzo(a,h)anthracene	1,123	2,389	0.389	14.1	0.0126	0.810	29.3	0.0261	3.26	118	0.105	5.01	96.7	0.0861	3.12	76.5	0.0681
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$					**1.10**			**1.75**			**9.77**			**30.3**			**5.47**
Adjusted $ESTBU_{FCVi}$ [1]					**3.01**			**4.82**			**26.9**			**83.2**			**15.0**

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicological contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Vali

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-A-07 (TOC = 3.81%; f_{OC} = 0.0381)			SD-A-08 (TOC = 3.39%; f_{OC} = 0.0339)			SD-A-09 (TOC = 3.44%; f_{OC} = 0.0344)			SD-A-10 (TOC = 3.08%; f_{OC} = 0.0308)			SD-A-11 (TOC = 2.84%; f_{OC} = 0.0284)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	0.577	15.1	0.0393	0.216	6.37	0.0165	0.110	3.20	0.00831	2.90	94.2	0.245	0.0796	2.803	0.00728
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	7.28	191	0.423	1.36	40.1	0.0888	1.71	49.7	0.110	0.547	17.8	0.0393	0.478	16.8	0.0372
Acenaphthene	491	13.6	357	0.727	0.914	27.0	0.0549	0.40	11.5	0.0234	0.587	19.1	0.0388	0.195	6.87	0.0140
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	3.83	101	0.187	0.730	21.5	0.0400	0.555	16.1	0.0300	0.566	18.4	0.0342	0.167	5.88	0.0109
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	8.42	221	0.372	2.12	62.5	0.105	1.69	49.1	0.0827	0.673	21.9	0.0368	0.529	18.6	0.0314
Phenanthrene	596	15.1	396	0.665	5.07	150	0.251	4.33	126	0.211	2.30	74.7	0.125	0.946	33.3	0.0559
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	56.8	1491	2.139	12.8	378	0.542	11.4	331	0.475	4.26	138	0.198	3.70	130	0.187
Fluoranthene	707	91.3	2396	3.389	20.0	590	0.834	15.9	462	0.654	6.27	204	0.288	5.70	201	0.284
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	32.0	840	0.999	9.33	275	0.327	7.31	213	0.253	2.37	76.9	0.0915	2.22	78.2	0.0929
Chrysene	844	26.7	701	0.830	7.17	212	0.251	5.98	174	0.206	2.06	66.9	0.0792	2.00	70.4	0.0834
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	25.4	667	0.691	8.13	240	0.249	7.61	221	0.229	2.34	76.0	0.0787	2.25	79.2	0.0821
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	23.2	609	0.622	8.18	241	0.246	7.49	218	0.222	2.30	74.7	0.0763	2.10	73.9	0.0755
Benzo(k)fluoranthene	981	16.1	423	0.431	5.98	176	0.180	5.45	158	0.161	1.52	49.4	0.0503	0.955	33.6	0.0343
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	15.4	404	0.369	3.32	97.9	0.0894	3.20	93.0	0.0850	0.685	22.2	0.0203	0.691	24.3	0.0222
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	15.1	396	0.355	3.49	103	0.0923	3.22	93.6	0.0840	0.748	24.3	0.0218	0.742	26.1	0.0234
Dibenzo(a,h)anthracene	1,123	5.28	139	0.123	0.897	26.5	0.0236	0.851	24.7	0.0220	0.366	11.9	0.0106	0.370	13.0	0.0116
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				**12.4**			**3.39**			**2.86**			**1.43**			**1.05**
Adjusted $ESTBU_{FCVi}$[1]				**34.0**			**9.32**			**7.86**			**3.94**			**2.90**

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-A-12 (TOC = 2.74%; f_{OC} = 0.0274)			SD-A-13 (TOC = 2.59%; f_{OC} = 0.0259)			SD-A-14 (TOC = 3.06%; f_{OC} = 0.0306)			SD-A-15 (TOC = 3.33%; f_{OC} = 0.0333)			SD-A-16 (TOC = 3.33%; f_{OC} = 0.0333)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	*1.63*	*59.5*	*0.155*	*0.0705*	*2.72*	*0.00707*	*0.0952*	*3.11*	*0.00808*	*0.219*	*6.58*	*0.0171*	*0.043*	*1.28*	*0.00333*
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.436	15.9	0.0352	0.247	9.54	0.0211	0.288	9.41	0.0208	0.236	7.09	0.0157	0.119	3.57	0.00790614
Acenaphthene	491	0.912	33.3	0.0678	0.132	5.10	0.0104	0.264	8.63	0.0176	0.526	15.8	0.0322	0.174	5.23	0.0106
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.743	27.1	0.0504	0.119	4.59	0.00854	0.199	6.50	0.0121	0.571	17.1	0.0319	0.161	4.83	0.00899
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.752	27.4	0.0462	0.359	13.9	0.0233	0.490	16.0	0.0270	1.10	33.0	0.0556	0.519	15.6	0.0262
Phenanthrene	596	2.79	102	0.171	0.610	23.6	0.0395	0.941	30.8	0.0516	3.74	112	0.188	1.73	52.0	0.0872
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	4.08	149	0.214	2.13	82.2	0.118	2.78	90.8	0.130	6.01	180	0.259	3.04	91.3	0.131
Fluoranthene	707	4.32	158	0.223	2.77	107	0.151	3.70	121	0.171	5.09	153	0.216	2.78	83.5	0.118
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	2.13	77.7	0.0924	0.886	34.2	0.0407	1.09	35.6	0.0424	3.08	92.5	0.110	0.991	29.8	0.0354
Chrysene	844	1.92	70.1	0.0830	1.04	40.2	0.0476	1.05	34.3	0.0407	3.24	97.3	0.115	1.46	43.8	0.0519
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	2.24	81.8	0.0847	0.972	37.5	0.0389	1.19	38.9	0.0403	3.11	93.4	0.0968	0.977	29.3	0.0304
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	2.20	80.3	0.0820	1.06	40.9	0.0418	1.73	56.5	0.0577	3.09	92.8	0.0948	0.913	27.4	0.0280
Benzo(k)fluoranthene	981	1.89	69.0	0.0703	0.695	26.8	0.0274	1.04	34.0	0.0346	2.66	79.9	0.0814	0.986	29.6	0.0302
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.712	26.0	0.0237	0.413	15.9	0.0146	0.468	15.3	0.0140	0.948	28.5	0.0260	0.360	10.8	0.00987
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.743	27.1	0.0243	0.439	16.9	0.0152	0.503	16.4	0.0147	0.965	29.0	0.0260	0.394	11.8	0.0106
Dibenzo(a,h)anthracene	1,123	0.266	9.71	0.0086	0.231	8.92	0.00794	0.257	8.40	0.00748	0.509	15.3	0.0136	0.188	5.65	0.00503
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				**1.43**			0.613			0.690			**1.38**			0.595
Adjusted $ESTBU_{FCVi}$[1]				**3.93**			**1.69**			**1.90**			**3.79**			**1.64**

Equations

C_{OC} = *Concentration/TOC*

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-A-17 (TOC = 3.33%; f_{OC} = 0.0333)			SD-A-18 (TOC = 2.43%; f_{OC} = 0.0243)			SD-A-18DUP (TOC = 2.43%; f_{OC} = 0.0243)			SD-A-19 (TOC = 2.49%; f_{OC} = 0.0249)			SD-A-20 (TOC = 2.42%; f_{OC} = 0.0242)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	0.0335	1.01	0.00261	0.028	1.15	0.00298	0.0254	1.05	0.00271	0.0272	1.09	0.00284	0.0182	0.752	0.00195
C1 Naphthalene	444	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Acenaphthylene	452	0.127	3.81	0.00843005	0.109	4.49	0.00992	0.108	4.44	0.00983	0.0957	3.84	0.00850	0.0634	2.62	0.00580
Acenaphthene	491	0.0868	2.60	0.00530	0.049	2.01	0.00409	0.039	1.62	0.00329	0.0910	3.65	0.00744	0.0576	2.38	0.00485
C2 Naphthalenes	510	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fluorene	538	0.0866	2.60	0.00483	0.062	2.53	0.00470	0.053	2.18	0.00405	0.0948	3.81	0.00708	0.0526	2.17	0.00404
C3 Naphthalenes	581	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Anthracene	594	0.422	12.7	0.0213	0.193	7.94	0.0134	0.182	7.49	0.0126	0.260	10.4	0.0176	0.190	7.85	0.0132
Phenanthrene	596	0.611	18.3	0.0308	0.369	15.2	0.0255	0.291	12.0	0.0201	0.700	28.1	0.0472	0.401	16.6	0.0278
C1 Fluorenes	611	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C4 Naphthalenes	657	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C1 Phenanthrenes	670	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C2 Fluorenes	686	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pyrene	697	1.60	48.0	0.0689	0.765	31.5	0.0452	0.811	33.4	0.0479	1.98	79.5	0.114	0.867	35.8	0.0514
Fluoranthene	707	1.16	34.8	0.0492	0.796	32.8	0.0463	0.615	25.3	0.0358	1.68	67.5	0.0954	0.767	31.7	0.0448
C2 Phenanthrenes	746	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C3 Fluorenes	769	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C1 Fluoranthenes	770	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C3 Phenanthrenes	829	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Benzo(a)anthracene	841	0.714	21.4	0.0255	0.477	19.6	0.0233	0.372	15.3	0.0182	0.584	23.5	0.0279	0.447	18.5	0.0220
Chrysene	844	0.559	16.8	0.0199	0.414	17.0	0.0202	0.459	18.9	0.0224	0.692	27.8	0.0329	0.478	19.8	0.0234
C4 Phenanthrenes	913	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C1 Chrysenes	929	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Benzo(a)pyrene	965	0.641	19.2	0.0199	0.483	19.9	0.0206	0.461	19.0	0.0197	0.692	27.8	0.0288	0.469	19.4	0.0201
Perylene	967	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Benzo(e)pyrene	967	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Benzo(b)fluoranthene	979	0.765	23.0	0.0234	0.650	26.7	0.0273	0.455	18.7	0.0191	0.702	28.2	0.0288	0.390	16.1	0.0165
Benzo(k)fluoranthene	981	0.465	14.0	0.0142	0.322	13.3	0.0135	0.403	16.6	0.0169	0.573	23.0	0.0235	0.418	17.3	0.0176
C2 Chrysenes	1,008	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Benzo(g,h,i)perylene	1,095	0.278	8.34	0.0076172	0.285	11.7	0.0107	0.182	7.49	0.00684	0.282	11.3	0.0103	0.227	9.38	0.0086
C3 Chrysenes	1,112	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Indeno(1,2,3-cd)pyrene	1,115	0.358	10.7	0.00963	0.320	13.2	0.0118	0.188	7.74	0.00694	0.297	11.9	0.0107	0.234	9.67	0.00867
Dibenzo(a,h)anthracene	1,123	0.203	6.09	0.00542	0.168	6.91	0.00616	0.112	4.61	0.00410	0.178	7.15	0.00637	0.101	4.17	0.00372
C4 Chrysenes	1,214	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sum total of $ESTBU_{FCVi}$				0.317			0.286			0.250			0.469			0.274
Adjusted $ESTBU_{FCVi}$ [1]				0.872			0.786			0.689			**1.29**			0.754

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-A-21 (TOC = 2.79%; f_{OC} = 0.0279)			SD-A-22 (TOC = 2.82%; f_{OC} = 0.0282)			SD-A-23 (TOC = 2.91%; f_{OC} = 0.0291)			SD-A-24 (TOC = 2.84%; f_{OC} = 0.0284)			SD-A-25 (TOC = 2.35%; f_{OC} = 0.0235)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	0.0551	1.97	0.00513	0.0558	1.98	0.00514	0.0308	1.06	0.00275	0.0651	2.29	0.00595	0.0472	2.01	0.00522
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.147	5.27	0.0117	0.213	7.55	0.0167	0.161	5.53	0.0122	0.375	13.2	0.0292	0.300	12.8	0.0282
Acenaphthene	491	0.0766	2.75	0.00559	0.131	4.65	0.00946	0.0667	2.29	0.00467	0.172	6.06	0.0123	0.120	5.11	0.01039997
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.0978	3.51	0.00652	0.115	4.08	0.00758	0.0708	2.43	0.00452	0.182	6.41	0.0119	0.103	4.38	0.00815
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.286	10.3	0.0173	0.387	13.7	0.0231	0.220	7.56	0.0127	0.590	20.8	0.0350	0.352	15.0	0.0252
Phenanthrene	596	0.474	17.0	0.0285	0.635	22.5	0.0378	0.375	12.9	0.0216	1.00	35.2	0.0591	0.528	22.5	0.0377
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	1.14	40.9	0.0586	1.58	56.0	0.0804	1.11	38.1	0.0547	3.99	140	0.202	2.22	94.5	0.136
Fluoranthene	707	1.06	38.0	0.0537	1.94	68.8	0.0973	0.948	32.6	0.0461	2.89	102	0.144	2.89	123.0	0.174
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	0.588	21.1	0.0251	0.91	32.2	0.0383	0.525	18.0	0.0215	1.64	57.7	0.0687	0.894	38.0	0.0452
Chrysene	844	0.771	27.6	0.0327	1.03	36.5	0.0433	0.615	21.1	0.0250	0.951	33.5	0.0397	0.968	41.2	0.0488
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	0.681	24.4	0.0253	1.04	36.9	0.0382	0.639	22.0	0.0228	1.55	54.6	0.0566	1.04	44.3	0.0459
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.590	21.1	0.0216	1.17	41.5	0.0424	0.721	24.8	0.0253	1.47	51.8	0.0529	1.08	46.0	0.0469
Benzo(k)fluoranthene	981	0.547	19.6	0.0200	0.587	20.8	0.0212	0.352	12.1	0.0123	0.804	28.3	0.0289	0.768	32.7	0.0333
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.394	14.1	0.0129	0.502	17.8	0.0163	0.321	11.0	0.0101	0.534	18.8	0.0172	0.444	18.9	0.0173
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.378	13.5	0.0122	0.505	17.9	0.0161	0.317	10.9	0.00977	0.680	23.9	0.0215	0.454	19.3	0.0173
Dibenzo(a,h)anthracene	1,123	0.232	8.32	0.00740	0.254	9.01	0.00802	0.198	6.80	0.00606	0.341	12.0	0.0107	0.226	9.62	0.00856
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.344			0.501			0.292			0.795			0.688
Adjusted $ESTBU_{FCVi}$[1]				0.946			**1.38**			0.803			**2.19**			**1.89**

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-A-26 (TOC = 2.65%; f_{OC} = 0.0265)			SD-A-27 (TOC = 3.25%; f_{OC} = 0.0325)			SD-A-28 (TOC = 2.48%; f_{OC} = 0.0248)			SD-A-29 (TOC = 3.09%; f_{OC} = 0.0309)			SD-A-30 (TOC = 2.69%; f_{OC} = 0.0269)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	0.14	5.13	0.0133	0.050	1.53	0.00397	0.025	0.996	0.00259	0.0230	0.744	0.00193	4.90E-04	1.82E-02	4.73E-05
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.15	5.51	0.0122	0.62	19.0	0.0421	0.39	15.5	0.0343	0.234	7.57	0.0168	0.117	4.35E+00	9.62E-03
Acenaphthene	491	0.092	3.47	0.00706	0.17	5.32	0.0108	0.057	2.29	0.00466	0.0592	1.92	0.00390	0.0268	9.96E-01	2.03E-03
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.079	2.98	0.00554	0.19	5.72	0.01063769	0.055	2.20	0.00408	0.0598	1.94	0.00360	0.0257	9.55E-01	1.78E-03
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.23	8.60	0.0145	0.73	22.4	0.0377	0.36	14.5	0.0244	0.176	5.70	0.00959	0.0787	2.93E+00	4.93E-03
Phenanthrene	596	0.40	15.2	0.0255	1.05	32.3	0.0542	0.31	12.7	0.0212	0.272	8.80	0.0148	0.139	5.17E+00	8.67E-03
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	0.87	32.7	0.0469	4.06	125	0.179	1.15	46.4	0.0665	0.871	28.2	0.0404	0.396	1.47E+01	2.11E-02
Fluoranthene	707	0.85	31.9	0.0451	5.35	165	0.233	1.21	48.8	0.0690	1.32	42.7	0.0604	0.572	2.13E+01	3.01E-02
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	0.57	21.4	0.0254	2.55	78.5	0.0933	0.73	29.4	0.0350	0.596	19.3	0.0229	0.277	1.03E+01	1.22E-02
Chrysene	844	0.39	14.7	0.0174	2.32	71.4	0.0846	0.79	31.8	0.0376	0.491	15.9	0.0188	0.233	8.66E+00	1.03E-02
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	0.48	17.9	0.0186	2.47	76.0	0.0788	1.02	41.1	0.0426	0.806	26.1	0.0270	0.331	1.23E+01	1.28E-02
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.59	22.4	0.0229	2.18	67.1	0.0685	1.21	48.8	0.0498	0.839	27.2	0.0277	0.264	9.81E+00	1.00E-02
Benzo(k)fluoranthene	981	0.37	14.1	0.0143	2.23	68.6	0.0699	0.70	28.3	0.0289	0.522	16.9	0.0172	0.287	1.07E+01	1.09E-02
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.16	5.89	0.00538	1.03	31.7	0.0289	0.39	15.6	0.0142	0.377	12.2	0.0111	0.170	6.32E+00	5.77E-03
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.24	9.13	0.00819	1.05	32.3	0.0290	0.43	17.5	0.0157	0.480	15.5	0.0139	0.205	7.62E+00	6.83E-03
Dibenzo(a,h)anthracene	1,123	0.11	4.11	0.00366	0.52	15.9	0.0142	0.22	8.67	0.00772	0.234	7.573	0.00674	0.105	3.90E+00	3.48E-03
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.286			**1.04**			0.458			0.297			0.151
Adjusted $ESTBU_{FCVi}$[1]				0.786			**2.86**			**1.26**			0.817			0.414

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g$_{OC}$)	SD-A-31 (TOC = 2.97%; f_{OC} = 0.0297)			SD-A-32 (TOC = 2.67%; f_{OC} = 0.0267)			SD-A-33 (TOC = 2.61%; f_{OC} = 0.0261)			SD-A-33DUP (TOC = 2.64%; f_{OC} =0.0264)			SD-A-34 (TOC = 2.94%; f_{OC} = 0.0294)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g$_{OC}$)	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g$_{OC}$)	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g$_{OC}$)	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g$_{OC}$)	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g$_{OC}$)	$ESTBU_{FCVi}$
Naphthalene	385	4.90E-04	1.65E-02	4.29E-05	0.0195	0.730	0.00190	0.0212	0.812	0.00211	0.031	1.16	0.00301	0.027	0.922	0.00239
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.128	4.31E+00	9.53E-03	0.152	5.69	0.0126	0.146	5.59	0.0124	0.12	4.70	0.0104	0.096	3.26	0.00721
Acenaphthene	491	0.0297	1.00E+00	2.04E-03	0.0530	1.99	0.00404	0.0534	2.05	0.00417	0.048	1.81	0.00368	0.042	1.41	0.00287
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.0488	1.64E+00	3.05E-03	0.0581	2.18	0.00404	0.0589	2.26	0.00419	0.055	2.08	0.00387	0.065	2.21	0.00411
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.0980	3.30E+00	5.55E-03	0.161	6.03	0.0102	0.173	6.63	0.0112	0.18	6.70	0.0113	0.30	10.1	0.0170
Phenanthrene	596	0.258	8.69E+00	1.46E-02	0.289	10.8	0.0182	0.288	11.0	0.0185	0.29	10.8	0.0182	0.30	10.1	0.0169
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	0.491	1.65E+01	2.37E-02	0.650	24.3	0.0349	0.668	25.6	0.0367	0.88	33.5	0.0480	0.77	26.1	0.0374
Fluoranthene	707	0.687	2.31E+01	3.27E-02	0.890	33.3	0.0471	0.970	37.2	0.0526	0.65	24.7	0.0350	0.63	21.6	0.0305
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	0.290	9.76E+00	1.16E-02	0.430	16.1	0.0191	0.455	17.4	0.0207	0.44	16.7	0.0198	0.37	12.4	0.0148
Chrysene	844	0.250	8.42E+00	9.97E-03	0.367	13.7	0.0163	0.415	15.9	0.0188	0.59	22.5	0.0266	0.51	17.2	0.0204
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	0.360	1.21E+01	1.26E-02	0.533	20.0	0.0207	0.545	20.9	0.0216	0.47	17.8	0.0184	0.41	13.9	0.0145
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.292	9.83E+00	1.00E-02	0.416	15.6	0.0159	0.440	16.9	0.0172	0.44	16.6	0.0169	0.37	12.6	0.0129
Benzo(k)fluoranthene	981	0.334	1.12E+01	1.15E-02	0.515	19.3	0.0197	0.542	20.8	0.0212	0.55	20.7	0.0211	0.36	12.2	0.0124
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.188	6.33E+00	5.78E-03	0.248	9.29	0.00848	0.236	9.04	0.00826	0.19	7.08	0.00647	0.22	7.38	0.00674
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.223	7.51E+00	6.73E-03	0.307	11.5	0.0103	0.298	11.4	0.0102	0.19	7.31	0.00656	0.21	7.24	0.00650
Dibenzo(a,h)anthracene	1,123	0.113	3.80E+00	3.39E-03	0.157	5.88	0.00524	0.155	5.94	0.00529	0.092	3.48	0.00310	0.13	4.35	0.00388
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.163			0.249			0.265			0.252			0.210
Adjusted $ESTBU_{FCVi}$[1]				0.448			0.684			0.729			0.694			0.579

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-A-35 (TOC = 2.42%; f_{OC} = 0.0242)			SD-A-36 (TOC = 2.49%; f_{OC} = 0.0249)			SD-A-37 (TOC = 2.43%; f_{OC} = 0.0243)			SD-A-38 (TOC = 2.24%; f_{OC} = 0.0224)			SD-A-39 (TOC = 1.98%; f_{OC} = 0.0198)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	0.030	1.26	0.00326	0.0659	2.65	0.00687	0.0153	0.630	0.00164	0.0289	1.29	0.00335	0.0279	1.41	0.00366
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.13	5.50	0.0122	0.278	11.16	0.0247	0.081	3.34	0.00739	0.112	5.00	0.0111	0.116	5.86	0.0130
Acenaphthene	491	0.084	3.46	0.00705	0.243	9.76	0.0199	0.024	0.975	0.00199	0.074	3.31	0.00675	0.064	3.25	0.00661
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.078	3.21	0.00597	0.160	6.43	0.0119	0.034	1.42	0.00263	0.077	3.46	0.00642	0.073	3.69	0.00685
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.23	9.34	0.0157	0.810	32.5	0.0548	0.095	3.92	0.00660	0.226	10.1	0.0170	0.186	9.39	0.0158
Phenanthrene	596	0.46	19.0	0.0319	0.748	30.0	0.0504	0.167	6.87	0.0115	0.463	20.7	0.0347	0.439	22.2	0.0372
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	1.30	53.7	0.0771	4.00	161	0.230	0.493	20.3	0.0291	0.869	38.8	0.0557	0.707	35.7	0.0512
Fluoranthene	707	0.89	36.8	0.0521	5.28	212	0.300	0.328	13.5	0.0191	0.845	37.7	0.0534	1.020	51.5	0.0729
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	0.60	24.7	0.0294	2.16	86.7	0.103	0.229	9.42	0.0112	0.448	20.0	0.0238	0.455	23.0	0.0273
Chrysene	844	0.76	31.5	0.0374	1.95	78.3	0.0928	0.291	12.0	0.0142	0.521	23.3	0.0276	0.501	25.3	0.0300
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	0.64	26.2	0.0272	1.76	70.7	0.0732	0.261	10.7	0.0111	0.535	23.9	0.0248	0.537	27.1	0.0281
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.60	24.8	0.0253	1.65	66.3	0.0677	0.238	9.79	0.0100	0.666	29.7	0.0304	0.453	22.9	0.0234
Benzo(k)fluoranthene	981	0.58	23.8	0.0242	0.605	24.3	0.0248	0.226	9.30	0.00948	0.300	13.4	0.0137	0.512	25.9	0.0264
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.30	12.2	0.0111	0.439	17.6	0.0161	0.113	4.65	0.00425	0.240	10.7	0.00978	0.213	10.8	0.00982
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.30	12.3	0.0110	0.474	19.0	0.0171	0.114	4.69	0.00421	0.243	10.8	0.00973	0.304	15.4	0.0138
Dibenzo(a,h)anthracene	1,123	0.18	7.56	0.00673	0.253	10.2	0.00905	0.068	2.79	0.00249	0.122	5.45	0.00485	0.103	5.20	0.00463
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.378			**1.10**			0.147			0.333			0.371
Adjusted $ESTBU_{FCVi}$[1]				**1.04**			**3.03**			0.404			0.915			**1.02**

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-A-40 (TOC = 2.34%; f_{OC} = 0.0234) Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	SD-A-41 (TOC = 2.31%; f_{OC} = 0.0231) Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	SD-A-42 (TOC = 4.36%; f_{OC} = 0.0436) Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	SD-A-43 (TOC = 2.12%; fOC = 0.0212) Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	SD-A-43DUP (TOC = 2.30%; fOC = 0.0230) Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	0.0256	1.09	0.00284	0.029	1.26	0.00328	0.020	0.452	0.00117	0.032	1.52	0.00396	0.0261	1.13	0.00295
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.119	5.09	0.0113	0.12	5.06	0.0112	0.043	0.995	0.00220	0.145	6.84	0.0151	0.166	7.22	0.0160
Acenaphthene	491	0.0631	2.70	0.00549	0.049	2.13	0.00434	0.020	0.450	0.000916	0.051	2.41	0.00491	0.046	2.02	0.00411
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.0646	2.76	0.00513	0.061	2.63	0.00489	0.025	0.564	0.00105	0.063	2.99	0.00555867	0.0697	3.03	0.00563
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.199	8.50	0.0143	0.19	8.10	0.0136	0.070	1.61	0.00271	0.194	9.15	0.0154	0.177	7.70	0.0130
Phenanthrene	596	0.386	16.5	0.0277	0.32	13.6	0.0229	0.129	2.96	0.00496	0.317	15.0	0.0251	0.343	14.9	0.0250
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	0.812	34.7	0.0498	0.910	39.4	0.0565	0.283	6.49	0.00931	0.941	44.4	0.0637	0.727	31.6	0.0453
Fluoranthene	707	0.773	33.0	0.0467	0.636	27.5	0.0389	0.264	6.06	0.00856	0.721	34.0	0.0481	1.02	44.3	0.0627
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	0.432	18.5	0.0220	0.462	20.0	0.0238	0.154	3.53	0.00420	0.471	22.2	0.0264	0.504	21.9	0.0261
Chrysene	844	0.505	21.6	0.0256	0.641	27.7	0.0329	0.181	4.15	0.00492	0.635	30.0	0.0355	0.503	21.9	0.0259
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	0.521	22.3	0.0231	0.489	21.2	0.0219	0.166	3.81	0.00395	0.560	26.4	0.0274	0.572	24.9	0.0258
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.460	19.7	0.0201	0.440	19.0	0.0195	0.167	3.83	0.00391	0.636	30.0	0.0306	0.495	21.5	0.0220
Benzo(k)fluoranthene	981	0.509	21.8	0.0222	0.475	20.6	0.0210	0.139	3.19	0.00325	0.338	15.9	0.0163	0.549	23.9	0.0243
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.219	9.36	0.00855	0.200	8.66	0.00791	0.067	1.53	0.00139	0.248	11.7	0.0107	0.252	11.0	0.0100
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.228	9.74	0.00874	0.206	8.92	0.00800	0.098	2.24	0.00201	0.251	11.8	0.0106	0.347	15.1	0.0135
Dibenzo(a,h)anthracene	1,123	0.117	5.00	0.00445	0.101	4.37	0.00389	0.039	0.890	0.00079	0.122	5.75	0.00512	0.121	5.26	0.00468
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.298			0.295			0.0553			0.344			0.327
Adjusted $ESTBU_{FCVi}$[1]				0.819			0.810			0.152			0.947			0.899

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-A-44 (TOC = 2.66%; fOC = 0.0266)			SD-A-45 (TOC = 3.23%; fOC = 0.0323)			SD-A-46 (TOC = 2.28%; f_{OC} = 0.0228)			SD-A-47 (TOC = 3.60%; f_{OC} = 0.0360)			SD-B-01 (TOC = 2.10%; f_{OC} = 0.0210)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	0.0407	1.53	0.00397	0.0137	0.424	0.00110	0.0291	1.28	0.00332	0.0303	0.842	0.00219	4.05E-04	1.93E-02	5.01E-05
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.181	6.80	0.0151	0.119	3.68	0.00815	0.131	5.75	0.0127	0.253	7.03	0.0155	0.0583	2.78E+00	6.14E-03
Acenaphthene	491	0.0659	2.48	0.00505	0.0257	0.796	0.00162	0.0628	2.75	0.00561	0.0497	1.38	0.00281	0.0156	7.43E-01	1.51E-03
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.0955	3.59	0.00667	0.0345	1.07	0.00199	0.0707	3.10	0.00576	0.0623	1.73	0.00322	0.0254	1.21E+00	2.25E-03
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.365	13.7	0.0231	0.0919	2.85	0.00479	0.163	7.15	0.0120	0.228	6.33	0.0107	0.0665	3.17E+00	5.33E-03
Phenanthrene	596	0.616	23.2	0.0389	0.144	4.46	0.00748	0.300	13.2	0.0221	0.285	7.92	0.013283	0.113	5.38E+00	9.03E-03
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	1.46	54.9	0.0787	0.417	12.9	0.0185	0.678	29.7	0.0427	1.10	30.6	0.0438	0.346	1.65E+01	2.36E-02
Fluoranthene	707	1.66	62.4	0.0883	0.538	16.7	0.0236	0.610	26.8	0.0378	1.54	42.8	0.0605	0.238	1.13E+01	1.60E-02
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	0.812	30.5	0.0363	0.265	8.20	0.00976	0.460	20.2	0.0240	0.782	21.7	0.0258	0.169	8.05E+00	9.57E-03
Chrysene	844	0.617	23.2	0.0275	0.236	7.31	0.00866	0.434	19.0	0.0226	0.792	22.0	0.0261	0.215	1.02E+01	1.21E-02
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	0.779	29.3	0.0303	0.355	11.0	0.0114	0.434	19.0	0.0197	0.801	22.3	0.0231	0.198	9.43E+00	9.77E-03
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.718	27.0	0.0276	0.401	12.4	0.0127	0.480	21.1	0.0215	0.727	20.2	0.0206	0.183	8.71E+00	8.90E-03
Benzo(k)fluoranthene	981	0.574	21.6	0.0220	0.214	6.63	0.00675	0.227	9.96	0.01014897	0.733	20.4	0.0208	0.171	8.14E+00	8.30E-03
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.245	9.21	0.00841	0.152	4.71	0.00430	0.196	8.60	0.00785	0.439	12.2	0.0111	0.0805	3.83E+00	3.50E-03
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.323	12.1	0.0109	0.187	5.79	0.00519	0.217	9.52	0.00854	0.579	16.1	0.0144	0.0803	3.82E+00	3.43E-03
Dibenzo(a,h)anthracene	1,123	0.179	6.73	0.00599	0.100	3.09	0.00275	0.103	4.52	0.00402	0.266	7.39	0.00658	0.0469	2.23E+00	1.99E-03
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.429			0.129			0.260			0.301			0.122
Adjusted $ESTBU_{FCVi}$[1]				**1.18**			0.354			0.716			0.826			0.334

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

		SD-B-02 (TOC = 2.03%; f_{OC} = 0.0203)			SD-B-03 (TOC = 2.48%; f_{OC} = 0.0248)			SD-B-04 (TOC = 2.16%; f_{OC} = 0.0216)			SD-B-05 (TOC = 2.23%; f_{OC} = 0.0223)			SD-B-06 (TOC = 2.44%; f_{OC} = 0.0244)		
	$C_{OC, PAHi, FCVi}$	Concentration	C_{OC}		Concentration	C_{OC}		Concentration	C_{OC}		Concentration	C_{OC}		Concentration	C_{OC}	
Chemical	*(ug/g$_{OC}$)*	*(ug/g dry wt.)*	*(ug/g$_{OC}$)*	*ESTBU$_{FCVi}$*	*(ug/g dry wt.)*	*(ug/g$_{OC}$)*	*ESTBU$_{FCVi}$*	*(ug/g dry wt.)*	*(ug/g$_{OC}$)*	*ESTBU$_{FCVi}$*	*(ug/g dry wt.)*	*(ug/g$_{OC}$)*	*ESTBU$_{FCVi}$*	*(ug/g dry wt.)*	*(ug/g$_{OC}$)*	*ESTBU$_{FCVi}$*
Naphthalene	385	0.0319	1.57	0.00408	0.0408	1.65	0.00427	0.0204	0.944	0.00245	0.0237	1.06	0.00276	0.0142	0.582	0.00151
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.106	5.22	0.0116	0.107	4.31	0.00955	0.102	4.72	0.0104	0.138	6.19	0.014	0.116	4.75	0.011
Acenaphthene	491	0.0492	2.42	0.00494	0.0530	2.14	0.00435	0.0331	1.53	0.00312	0.0466	2.09	0.00426	0.0283	1.16	0.00236
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.0622	3.06	0.00570	0.0675	2.72	0.00506	0.0461	2.13	0.00397	0.0547	2.45	0.00456	0.0342	1.40	0.00261
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.161	7.93	0.0134	0.202	8.15	0.0137	0.124	5.74	0.00966	0.155	6.95	0.012	0.102	4.18	0.00704
Phenanthrene	596	0.329	16.2	0.0272	0.370	14.9	0.0250	0.213	9.86	0.0165	0.274	12.3	0.021	0.157	6.43	0.011
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	0.812	40.0	0.0574	0.788	31.8	0.0456	0.648	30.0	0.0430	0.631	28.3	0.041	0.452	18.5	0.027
Fluoranthene	707	0.579	28.5	0.0403	0.767	30.9	0.0437	0.451	20.9	0.0295	0.867	38.9	0.055	0.573	23.5	0.033
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	0.403	19.9	0.0236	0.530	21.4	0.0254	0.329	15.2	0.0181	0.436	19.6	0.023	0.287	11.8	0.014
Chrysene	844	0.544	26.8	0.0318	0.385	15.5	0.0184	0.422	19.5	0.0231	0.439	19.7	0.023	0.256	10.5	0.012
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	0.442	21.8	0.0226	0.501	20.2	0.0209	0.354	16.4	0.0170	0.482	21.6	0.022	0.381	15.6	0.016
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.413	20.3	0.0208	0.688	27.7	0.0283	0.322	14.9	0.0152	0.404	18.1	0.019	0.460	18.9	0.019
Benzo(k)fluoranthene	981	0.402	19.8	0.0202	0.359	14.5	0.0148	0.287	13.3	0.0135	0.412	18.5	0.019	0.241	9.88	0.010
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.226	11.1	0.0102	0.176	7.10	0.00648	0.177	8.19	0.00748	0.241	10.8	0.00987	0.159	6.52	0.00595
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.224	11.0	0.00990	0.219	8.83	0.00792	0.179	8.29	0.00743	0.318	14.3	0.013	0.200	8.20	0.00735
Dibenzo(a,h)anthracene	1,123	0.105	5.17	0.00461	0.120	4.84	0.00431	0.083	3.85	0.00343	0.154	6.91	0.00615	0.104	4.26	0.00380
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.308			0.278			0.224			0.288			0.184
Adjusted $ESTBU_{FCVi}$[1]				0.847			0.764			0.616			0.793			0.505

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-B-07 (TOC = 3.08%; f_{OC} = 0.0308)			SD-B-08 (TOC = 2.58%; f_{OC} = 0.0258)			SD-B-09 (TOC = 2.65%; f_{OC} = 0.0265)			SD-B-10 (TOC = 4.26%; f_{OC} = 0.0426)			SD-B-11 (TOC = 2.89%; f_{OC} = 0.0289)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	0.0206	0.669	0.00174	0.0224	0.868	0.00226	0.0422	1.59	0.00414	0.213	5.00	0.0130	0.141	4.88	0.0127
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.152	4.94	0.011	0.189	7.33	0.016	0.164	6.19	0.0137	0.317	7.44	0.0165	0.230	7.96	0.0176
Acenaphthene	491	0.0411	1.33	0.00272	0.0482	1.87	0.00380	0.0771	2.91	0.00593	0.853	20.0	0.0408	0.091	3.13	0.00638
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.0490	1.59	0.00296	0.0550	2.13	0.00396	0.0778	2.94	0.00546	0.804	18.9	0.0351	0.15	5.26	0.00978
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.140	4.55	0.00765	0.172	6.67	0.011	0.212	8.00	0.0135	3.39	79.6	0.134	0.478	16.5	0.0278
Phenanthrene	596	0.221	7.18	0.012	0.257	9.96	0.017	0.385	14.5	0.0244	4.24	99.5	0.167	0.817	28.3	0.0474
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	0.539	17.5	0.025	0.719	27.9	0.040	0.857	32.3	0.0464	5.27	124	0.177	1.88	65.1	0.0933
Fluoranthene	707	0.786	25.5	0.036	0.993	38.5	0.054	0.992	37.4	0.0529	5.99	141	0.199	1.75	60.6	0.0856
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	0.375	12.2	0.014	0.473	18.3	0.022	0.485	18.3	0.0218	2.63	61.7	0.0734	0.827	28.6	0.0340
Chrysene	844	0.335	10.9	0.013	0.418	16.2	0.019	0.443	16.7	0.0198	2.58	60.6	0.0718	1.08	37.4	0.0443
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	0.477	15.5	0.016	0.630	24.4	0.025	0.622	23.5	0.0243	1.92	45.1	0.0467	0.796	27.5	0.0285
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.569	18.5	0.019	0.720	27.9	0.029	0.739	27.9	0.0285	1.80	42.3	0.0432	0.828	28.7	0.0293
Benzo(k)fluoranthene	981	0.292	9.48	0.00966	0.493	19.1	0.019	0.512	19.3	0.0197	1.05	24.6	0.0251	0.512	17.7	0.0181
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.189	6.14	0.00560399	0.234	9.07	0.00828	0.217	8.19	0.00748	0.540	12.7	0.0116	0.314	10.9	0.00992
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.239	7.76	0.00696	0.297	11.5	0.010	0.273	10.3	0.00924	0.568	13.3	0.0120	0.322	11.1	0.00999
Dibenzo(a,h)anthracene	1,123	0.127	4.12	0.00367	0.102	3.95	0.00352	0.150	5.66	0.00504	0.314	7.37	0.00656	0.158	5.47	0.00487
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.187			0.285			0.302			**1.07**			0.480
Adjusted $ESTBU_{FCVi}$ [1]				0.515			0.784			0.831			**2.95**			**1.32**

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-B-12 (TOC = 2.51%; f_{OC} = 0.0251)			SD-B-13 (TOC = 2.94%; f_{OC} = 0.0294)			SD-B-13DUP (TOC = 2.77%; f_{OC} = 0.0277)			SD-B-14 (TOC = 3.01%; f_{OC} = 0.0301)			SD-B-15 (TOC = 2.82%; f_{OC} = 0.0282)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	0.019	0.741	0.00192	0.077	2.61	0.00679	0.0258	0.931	0.00242	0.018	0.608	0.00157915	4.50E-04	1.60E-02	4.14E-05
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.104	4.14	0.00917	0.067	2.29	0.00506	0.0452	1.63	0.00361	0.140	4.651	0.010	0.108	3.83E+00	8.47E-03
Acenaphthene	491	0.026	1.04	0.00211	0.025	0.847	0.00172	0.0164	0.592	0.00121	0.038	1.246	0.00253737	0.025	8.83E-01	1.80E-03
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.036	1.43	0.00267	0.030	1.02	0.00189	0.0214	0.773	0.00144	0.046	1.532	0.00284677	0.035	1.26E+00	2.33E-03
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.109	4.34	0.00731	0.113	3.84	0.00647	0.0773	2.79	0.00470	0.130	4.319	0.00727094	0.085	3.00E+00	5.05E-03
Phenanthrene	596	0.146	5.82	0.00976	0.179	6.09	0.0102	0.121	4.37	0.00733	0.203	6.744	0.011	0.147	5.21E+00	8.75E-03
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	0.563	22.4	0.0322	0.369	12.6	0.0180	0.286	10.32	0.0148	0.510	16.944	0.024	0.323	1.15E+01	1.64E-02
Fluoranthene	707	0.400	15.9	0.0225	0.334	11.4	0.0161	0.265	9.57	0.0135	0.701	23.289	0.033	0.433	1.54E+01	2.17E-02
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	0.294	11.7	0.0139	0.215	7.31	0.00870	0.163	5.88	0.00700	0.359	11.927	0.014	0.215	7.62E+00	9.07E-03
Chrysene	844	0.357	14.2	0.0169	0.217	7.38	0.00875	0.199	7.18	0.00851	0.309	10.266	0.012	0.194	6.88E+00	8.15E-03
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	0.318	12.7	0.0131	0.226	7.69	0.00797	0.190	6.86	0.00711	0.454	15.083	0.016	0.289	1.02E+01	1.06E-02
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.279	11.1	0.0114	0.146	4.97	0.00507	0.110	3.97	0.00406	0.514	17.076	0.017	0.224	7.94E+00	8.11E-03
Benzo(k)fluoranthene	981	0.275	11.0	0.0112	0.151	5.14	0.00524	0.117	4.22	0.00431	0.284	9.435	0.00961796	0.306	1.09E+01	1.11E-02
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.135	5.38	0.00491	0.101	3.44	0.00314	0.0984	3.55	0.00324	0.188	6.246	0.00570397	0.110	3.90E+00	3.56E-03
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.138	5.50	0.00493	0.147	5.00	0.00448	0.126	4.55	0.00408	0.229	7.608	0.00682329	0.133	4.72E+00	4.23E-03
Dibenzo(a,h)anthracene	1,123	0.063	2.50	0.00223	0.064	2.19	0.00195	0.0545	1.97	0.00175	0.123	4.086	0.00363881	0.077	2.73E+00	2.43E-03
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.166			0.112			0.0891			0.178			0.122
Adjusted $ESTBU_{FCVi}$[1]				0.457			0.307			0.245			0.490			0.335

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-B-16 (TOC = 2.56%; f_{OC} = 0.0256)			SD-B-17 (TOC = 2.84%; f_{OC} = 0.0284)			SD-B-18 (TOC = 3.03%; f_{OC} = 0.0303)			SD-B-19 (TOC = 2.96%; f_{OC} = 0.0296)			SD-B-20 (TOC = 2.40%; f_{OC} = 0.0240)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	0.0508	1.98	0.00515	5.00E-04	1.76E-02	4.57E-05	4.70E-04	1.55E-02	4.03E-05	4.90E-04	1.66E-02	4.30E-05	4.30E-04	1.79E-02	4.65E-05
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.0899	3.51	0.00777	0.0900	3.17E+00	7.01E-03	0.0958	3.16E+00	6.99E-03	0.102	3.45E+00	7.62E-03	0.0758	3.16E+00	6.99E-03
Acenaphthene	491	0.0630	2.46	0.00501	7.00E-04	2.46E-02	5.02E-05	0.0155	5.12E-01	1.04E-03	0.0162	5.47E-01	1.11E-03	6.00E-04	2.50E-02	5.09E-05
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.0674	2.63	0.00489	8.00E-04	2.82E-02	5.24E-05	0.0309	1.02E+00	1.90E-03	0.0302	1.02E+00	1.90E-03	0.0224	9.33E-01	1.73E-03
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.269	10.5	0.0177	0.0537	1.89E+00	3.18E-03	0.0718	2.37E+00	3.99E-03	0.0697	2.35E+00	3.96E-03	0.0801	3.34E+00	5.62E-03
Phenanthrene	596	0.486	19.0	0.0319	0.0752	2.65E+00	4.44E-03	0.100	3.30E+00	5.54E-03	0.0936	3.16E+00	5.31E-03	0.0668	2.78E+00	4.67E-03
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	0.966	37.7	0.0541	0.205	7.22E+00	1.04E-02	0.230	7.59E+00	1.09E-02	0.244	8.24E+00	1.18E-02	0.161	6.71E+00	9.62E-03
Fluoranthene	707	1.19	46.5	0.0657	0.260	9.15E+00	1.29E-02	0.301	9.93E+00	1.41E-02	0.292	9.86E+00	1.40E-02	0.190	7.92E+00	1.12E-02
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	0.624	24.4	0.0290	0.145	5.11E+00	6.07E-03	0.154	5.08E+00	6.04E-03	0.174	5.88E+00	6.99E-03	0.110	4.58E+00	5.45E-03
Chrysene	844	0.488	19.1	0.0226	0.144	5.07E+00	6.01E-03	0.149	4.92E+00	5.83E-03	0.171	5.78E+00	6.84E-03	0.126	5.25E+00	6.22E-03
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	0.775	30.3	0.0314	0.160	5.63E+00	5.84E-03	0.210	6.93E+00	7.18E-03	0.227	7.67E+00	7.95E-03	0.138	5.75E+00	5.96E-03
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.646	25.2	0.0258	0.163	5.74E+00	5.86E-03	0.229	7.56E+00	7.72E-03	0.248	8.38E+00	8.56E-03	0.153	6.38E+00	6.51E-03
Benzo(k)fluoranthene	981	0.693	27.1	0.0276	0.106	3.73E+00	3.80E-03	0.138	4.55E+00	4.64E-03	0.143	4.83E+00	4.92E-03	0.0960	4.00E+00	4.08E-03
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.250	9.77	0.00892	0.0902	3.18E+00	2.90E-03	0.0789	2.60E+00	2.38E-03	0.0931	3.15E+00	2.87E-03	0.0477	1.99E+00	1.82E-03
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.278	10.9	0.00974	0.114	4.01E+00	3.60E-03	0.0927	3.06E+00	2.74E-03	0.106	3.58E+00	3.21E-03	0.0575	2.40E+00	2.15E-03
Dibenzo(a,h)anthracene	1,123	0.152	5.94	0.00529	0.0343	1.21E+00	1.08E-03	0.0389	1.28E+00	1.14E-03	0.0455	1.54E+00	1.37E-03	0.0244	1.02E+00	9.05E-04
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.353			0.0733			0.0821			0.0884			0.0730
Adjusted $ESTBU_{FCVi}$[1]				0.969			0.201			0.226			0.243			0.201

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1.- Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-B-21 (TOC = 2.58%; f_{OC} = 0.0258)			SD-B-22 (TOC = 2.70%; f_{OC} = 0.0270)			SD-B-23 (TOC = 2.53%; f_{OC} = 0.0253)			SD-B-24 (TOC = 2.47%; f_{OC} = 0.0247)			SD-B-27 (TOC = 2.93%; f_{OC} = 0.0293)		
		Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	0.0274	1.06	0.00276	4.95E-04	1.83E-02	4.76E-05	0.0192	0.759	0.00197	0.0215	0.870	0.00226	0.0230	0.785	2.04E-03
C1 Naphthalene	444	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	452	0.0892	3.46	0.00765	0.0634	2.35E+00	5.20E-03	0.0817	3.23	0.00714	0.0904	3.66	0.00810	0.101	3.45	7.63E-03
Acenaphthene	491	6.50E-04	0.0252	5.13E-05	6.50E-04	2.41E-02	4.90E-05	6.50E-04	0.0257	5.23E-05	6.50E-04	0.0263	5.36E-05	0.0205	0.700	1.42E-03
C2 Naphthalenes	510	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluorene	538	0.0322	1.25	0.00232	0.0276	1.02E+00	1.90E-03	0.0214	0.846	0.00157	0.038	1.55	0.00289	0.0292	0.997	1.85E-03
C3 Naphthalenes	581	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anthracene	594	0.130	5.04	0.00848	0.0685	2.54E+00	4.27E-03	0.0624	2.47	0.00415	0.145	5.87	0.00988	0.0970	3.31	5.57E-03
Phenanthrene	596	0.127	4.92	0.00826	0.100	3.70E+00	6.21E-03	0.0815	3.22	0.00540	0.156	6.32	0.0106	0.140	4.78	8.02E-03
C1 Fluorenes	611	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	697	0.359	13.9	0.0200	0.320	1.19E+01	1.70E-02	0.303	12.0	0.0172	0.441	17.9	0.0256	0.490	16.7	2.40E-02
Fluoranthene	707	0.434	16.8	0.0238	0.211	7.81E+00	1.11E-02	0.182	7.19	0.0102	0.473	19.1	0.0271	0.313	10.7	1.51E-02
C2 Phenanthrenes	746	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	841	0.193	7.48	0.00889	0.160	5.93E+00	7.05E-03	0.143	5.65	0.00672	0.288	11.7	0.0139	0.225	7.68	9.13E-03
Chrysene	844	0.251	9.73	0.0115	0.203	7.52E+00	8.91E-03	0.195	7.71	0.00913	0.241	9.76	0.0116	0.306	10.4	0.012374036
C4 Phenanthrenes	913	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	965	0.329	12.8	0.0132	0.190	7.04E+00	7.29E-03	0.171	6.76	0.00700	0.346	14.0	0.0145	0.262	8.94	9.27E-03
Perylene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.361	14.0	0.0143	0.158	5.85E+00	5.98E-03	0.143	5.65	0.00577	0.296	12.0	0.0122	0.220	7.51	7.67E-03
Benzo(k)fluoranthene	981	0.264	10.2	0.0104	0.129	4.78E+00	4.87E-03	0.168	6.64	0.00677	0.235	9.51	0.00970	0.273	9.32	9.50E-03
C2 Chrysenes	1,008	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.0731	2.83	0.00259	0.104	3.85E+00	3.52E-03	0.0662	2.62	0.00239	0.142	5.75	0.00525	0.111	3.79	3.46E-03
C3 Chrysenes	1,112	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.0774	3.00	0.00269	0.0970	3.59E+00	3.22E-03	0.0658	2.60	0.00233	0.144	5.83	0.00523	0.108	3.69	3.31E-03
Dibenzo(a,h)anthracene	1,123	0.0453	1.76	0.00156	0.0456	1.69E+00	1.50E-03	0.0268	1.06	0.000943	0.0744	3.01	0.00268	0.0456	1.56	1.39E-03
C4 Chrysenes	1,214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.138			0.0881			0.0887			0.162			0.122
Adjusted $ESTBU_{FCVi}$[1]				0.381			0.242			0.244			0.444			0.335

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH mixtures Based on the Final Chronic Valu

Chemical	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	SD-B-28 (TOC = 2.76%; f_{OC} = 0.0276) Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$	SD-B-29 (TOC = 2.85%; f_{OC} = 0.0285) Concentration (ug/g dry wt.)	C_{OC} (ug/g_{OC})	$ESTBU_{FCVi}$
Naphthalene	385	4.85E-04	1.76E-02	4.56E-05	5.00E-04	1.75E-02	4.56E-05
C1 Naphthalene	444	--	--	--	--	--	--
Acenaphthylene	452	0.0597	2.16	4.79E-03	0.0661	2.32	5.13E-03
Acenaphthene	491	0.0192	6.96E-01	1.42E-03	0.0192	0.67	1.37E-03
C2 Naphthalenes	510	--	--	--	--	--	--
Fluorene	538	0.0249	9.02E-01	1.68E-03	0.0326	1.14	2.13E-03
C3 Naphthalenes	581	--	--	--	--	--	--
Anthracene	594	0.0652	2.36	3.98E-03	0.0764	2.68	4.51E-03
Phenanthrene	596	0.107	3.88	6.50E-03	0.12	4.28	7.18E-03
C1 Fluorenes	611	--	--	--	--	--	--
C4 Naphthalenes	657	--	--	--	--	--	--
C1 Phenanthrenes	670	--	--	--	--	--	--
C2 Fluorenes	686	--	--	--	--	--	--
Pyrene	697	0.376	13.6	1.95E-02	0.375	13.2	1.89E-02
Fluoranthene	707	0.260	9.42	1.33E-02	0.270	9.47	1.34E-02
C2 Phenanthrenes	746	--	--	--	--	--	--
C3 Fluorenes	769	--	--	--	--	--	--
C1 Fluoranthenes	770	--	--	--	--	--	--
C3 Phenanthrenes	829	--	--	--	--	--	--
Benzo(a)anthracene	841	0.202	7.32	8.70E-03	0.190	6.67	7.93E-03
Chrysene	844	0.247	8.95	1.06E-02	0.236	8.28	9.81E-03
C4 Phenanthrenes	913	--	--	--	--	--	--
C1 Chrysenes	929	--	--	--	--	--	--
Benzo(a)pyrene	965	0.221	8.01	8.30E-03	0.226	7.93	8.22E-03
Perylene	967	--	--	--	--	--	--
Benzo(e)pyrene	967	--	--	--	--	--	--
Benzo(b)fluoranthene	979	0.190	6.88	7.03E-03	0.204	7.16	7.31E-03
Benzo(k)fluoranthene	981	0.211	7.64	7.79E-03	0.165	5.79	5.90E-03
C2 Chrysenes	1,008	--	--	--	--	--	--
Benzo(g,h,i)perylene	1,095	0.0858	3.11	2.84E-03	0.126	4.42	4.04E-03
C3 Chrysenes	1,112	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	1,115	0.0859	3.11	2.79E-03	0.118	4.14	3.71E-03
Dibenzo(a,h)anthracene	1,123	0.0538	1.95	1.74E-03	0.0562	1.97	1.76E-03
C4 Chrysenes	1,214	--	--	--	--	--	--
Sum total of $ESTBU_{FCVi}$				0.101			0.101
Adjusted $ESTBU_{FCVi}$[1]				0.278			0.279

Equations

C_{OC} = Concentration/TOC

$ESBTU_{FCVi} = C_{OC}/C_{OC, PAH, FCVi}$ (or $C_{OC, PAHi, Maxi}$ if C_{OC} exceeds the $C_{OC, PAHi, FCVi}$ value)

Notes

1 - Adjusted with a correction factor of 2.75 (50% confidence interval) to estimate the total PAH toxicologica contribution of the 34 PAHs from the 15 measured PAHs

C_{oc} = Chemical concentration in sediments on an organic carbon basis

$C_{OC, PAHi, FCVi}$ = Effect concentration of a PAH in sediment on an organic carbon basis calculated from the product of its FCV and Koc.

$C_{OC, PAHi, Maxi}$ = Maximum solubility limited PAH concentration in sediment on an organic carbon basis

$ESBTU_{FCVi}$ = Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the FCV

Sum total of ESBTU = Sum of Equilibrium Partitioning Sediment Benchmark Toxic Units (unitless)

FCV = Final Chronic Value

OC = Organic Carbon

PAH = Polycyclic Aromatic Hydrocarbon

TOC = Total Organic Carbon

TABLE B-7
Raccoon
Comparison of Raccoon Exposure Doses to Toxicity Reference Values

Chemical	Sediment Concentration	Sediment - Pant BCF	Aquatic Plant Concentration	Sediment - Invertebrate BAF	Aquatic Invertebrate Concentration	Sediment - Fish BAF	Fish Concentration	Surface Water	Dietary Intake	NOAEL TRV	LOAEL TRV	NOAEL HQ	LOAEL HQ
Arsenic	23.19	0.038	0.88	0.127	2.945348633	0.126	2.922156912	0	0.0697966	1.2	6	<1	<1
Acenaphthene	9.91	--	0.001	0.301	2.983266766	1.0	9.911185269	0	0.05079245	350	700	<1	<1
Acenaphthylene	1.31	--	0.003	0.301	0.394009	1.0	1.309	0	0.006729	350	700	<1	<1
Anthracene	4.80	--	1.261	0.301	1.443481895	1.0	4.795620915	0	0.03332675	1000	5000	<1	<1
Benzo(a)anthracene	6.72	--	0.207	0.301	2.022883913	1.0	6.720544563	0	0.03587532	2.00	10.0	<1	<1
Benzo(a)pyrene	6.01	--	0.732	0.301	1.809913	1.0	6.013	0	0.03589273	2.00	10.0	<1	<1
Benzo(b)fluoranthene	5.74	0.31	1.778	0.301	1.726837	1.0	5.737	0	0.04174607	2.00	10.0	<1	<1
Benzo(g,h,i)perylene	2.94	--	1.412	0.301	0.885542	1.0	2.942	0	0.02488056	2.00	10.0	<1	<1
Chrysene	6.00	--	0.193	0.301	1.805097	1.0	5.997	0	0.03207354	2.00	10.0	<1	<1
Dibenz(a,h)anthracene	1.11	0.13	0.144	0.301	0.333207	1.0	1.107	0	0.00667182	2.00	10.0	<1	<1
Fluoranthene	16.86	0.50	8.432	0.301	5.075941457	1.0	16.86359288	0	0.14495545	500	2500	<1	<1
Fluorene	19.61	--	0.000	0.301	5.90261	1.0	19.61	0	0.10049123	500	2500	<1	<1
Indeno(1,2,3-cd)pyrene	2.96	0.11	0.326	0.301	0.892164	1.0	2.964	0	0.01745229	1.00	10.0	<1	<1
Phenanthrene	18.42	--	5.159	0.301	5.54437457	1.0	18.41984907	0	0.13020652	500	5000	<1	<1
Pyrene	13.78	0.72	9.921	0.301	4.147716579	1.0	13.7797893	0	0.13949515	2.00	10.0	<1	<1
Total PAHs	123.5	--	13.934	0.301	37.1735	1.0	123.5	0	0.72960197	2.00	10.0	<1	<1

$$DI_x = \frac{\sum(FIR)(FC_{xi})(PDF_i) + [(FIR)(SC_x)(PDS) + [(WIR)(WCx)]}{BW}$$

DI = Chemical-specific = Dietary intake for chemical (mg chemical/kg body weight/day)
FIR = 0.1031 = Food ingestion rate (kg/day dry weight, from Table)
FCxi = Chemical-specific = Concentration of chemical in food item (plants, mg/kg, dry weight basis)
PDFi = 0.4 = Proportion of diet composed of food item (plants, dry weight basis, from Table)
FCxi = Chemical-specific = Concentration of chemical in food item (invertebrates, mg/kg, dry weight basis)
PDFi = 0.436 = Proportion of diet composed of food item (invertebrates, dry weight basis, from Table)
FCxi = Chemical-specific = Concentration of chemical in food item (fish, mg/kg, dry weight basis)
PDFi = 0.07 = Proportion of diet composed of food item (fish, dry weight basis, from Table)
SCx = Chemical-specific = Concentration of chemical in sediment (mg/kg, dry weight, maximum from Table)
PDS = 0.094 = Proportion of diet composed of sediment (dry weight basis, from Table)
WIR = 0.4921 = Water ingestion rate (L/day, from Table)
WCx = Chemical-specific = Concentration of chemical in water (mg/L, maximum from)
BW = 5.94 = Body weight (kg wet weight, minimum from Table)

$$HQ = \frac{DI_x}{\text{Screening Value (from Table)}}$$

TABLE B-8
Great Blue Heron
Comparison of Great Blue Heron Exposure Doses to Toxicity Reference Values

Chemical	Sediment Concentration	Sediment - Fish BAF	Fish Concentration	Surface Water	Dietary Intake	NOAEL TRV	LOAEL TRV	NOAEL HQ	LOAEL HQ
Arsenic	23.19	0.126	2.922156912	0	0.51511205	NA	2.24	<1	<1
Acenaphthene	9.91	1.0	9.911185269	0	1.74712418	7.10	71	<1	<1
Acenaphthylene	1.31	1.0	1.309	0	0.23074794	7.10	71	<1	<1
Anthracene	4.80	1.0	4.795620915	0	0.84536259	7.10	71	<1	<1
Benzo(a)anthracene	6.72	1.0	6.720544563	0	1.18468434	7.10	71	<1	<1
Benzo(a)pyrene	6.01	1.0	6.013	0	1.05995978	7.10	71	<1	<1
Benzo(b)fluoranthene	5.74	1.0	5.737	0	1.01130704	7.10	71	<1	<1
Benzo(g,h,i)perylene	2.94	1.0	2.942	0	0.51860996	7.10	71	<1	<1
Chrysene	6.00	1.0	5.997	0	1.05713933	7.10	71	<1	<1
Dibenz(a,h)anthracene	1.11	1.0	1.107	0	0.19513978	7.10	71	<1	<1
Fluoranthene	16.86	1.0	16.86359288	0	2.97268088	7.10	71	<1	<1
Fluorene	19.61	1.0	19.61	0	3.45681211	7.10	71	<1	<1
Indeno(1,2,3-cd)pyrene	2.96	1.0	2.964	0	0.52248807	7.10	71	<1	<1
Phenanthrene	18.42	1.0	18.41984907	0	3.24701465	7.10	71	<1	<1
Pyrene	13.78	1.0	13.7797893	0	2.42907407	7.10	71	<1	<1
Total PAHs	123.5	1.0	123.5	0	21.7703363	7.10	71	3	<1

$$DI_x = \frac{\sum(FIR)(FC_{xi})(PDF_i) + [(FIR)(SC_x)(PDS) + [(WIR)(WCx)]}{BW}$$

DI = Chemical-specific = Dietary intake for chemical (mg chemical/kg body weight/day)
FIR = 0.3931 = Food ingestion rate (kg/day dry weight, from Table)
FCxi = Chemical-specific = Concentration of chemical in food item (fish, mg/kg, dry weight basis)
PDFi = 1 = Proportion of diet composed of food item (fish, dry weight basis, from Table)
SCx = Chemical-specific = Concentration of chemical in sediment (mg/kg, dry weight, maximum from Table)
PDS = 0 = Proportion of diet composed of sediment (dry weight basis, from Table)
WIR = 0.101 = Water ingestion rate (L/day, from Table)
WCx = Chemical-specific = Concentration of chemical in water (mg/L, maximum from)
BW = 2.23 = Body weight (kg wet weight, minimum from Table)

$$HQ = \frac{DI_x}{\text{Screening Value (from Table)}}$$

TABLE B-9
Canada Goose
Comparison of Canada Goose Exposure Doses to Toxicity Reference Values

Chemical	Sediment Concentration	Sediment - Pant BCF	Aquatic Plant Concentration	Surface Water	Dietary Intake	NOAEL TRV	LOAEL TRV	NOAEL HQ	LOAEL HQ
Arsenic	23.19	0.038	0.881285418	0	0.556553015	NA	2.24	<1	<1
Acenaphthene	9.91	--	0.000539721	0	0.228305041	7.10	71	<1	<1
Acenaphthylene	1.31	--	0.003050707	0	0.030228532	7.10	71	<1	<1
Anthracene	4.80	--	1.26061559	0	0.142447706	7.10	71	<1	<1
Benzo(a)anthracene	6.72	--	0.206931505	0	0.160049726	7.10	71	<1	<1
Benzo(a)pyrene	6.01	--	0.731671012	0	0.157067056	7.10	71	<1	<1
Benzo(b)fluoranthene	5.74	0.31	1.77847	0	0.17727116	7.10	71	<1	<1
Benzo(g,h,i)perylene	2.94	--	1.412208956	0	0.103598463	7.10	71	<1	<1
Chrysene	6.00	--	0.193384384	0	0.143040068	7.10	71	<1	<1
Dibenz(a,h)anthracene	1.11	0.13	0.14391	0	0.029149877	7.10	71	<1	<1
Fluoranthene	16.86	0.50	8.43179644	0	0.602378906	7.10	71	<1	<1
Fluorene	19.61	--	0.00030103	0	0.45169865	7.10	71	<1	<1
Indeno(1,2,3-cd)pyrene	2.96	0.11	0.32604	0	0.076544827	7.10	71	<1	<1
Phenanthrene	18.42	--	5.158778917	0	0.555175931	7.10	71	<1	<1
Pyrene	13.78	0.72	9.921448296	0	0.569145801	7.10	71	<1	<1
Total PAHs	123.5	--	13.93404501	0	3.19822444	7.10	71	<1	<1

$$DI_x = \frac{\sum(FIR)(FC_{xi})(PDF_i) + [(FIR)(SC_x)(PDS) + [(WIR)(WCx)]}{BW}$$

DI = Chemical-specific = Dietary intake for chemical (mg chemical/kg body weight/day)
FIR = 0.0984 = Food ingestion rate (kg/day dry weight, from Table)
FCxi = Chemical-specific = Concentration of chemical in food item (fish, mg/kg, dry weight basis)
PDFi = 0.918 = Proportion of diet composed of food item (plants, dry weight basis, from Table)
SCx = Chemical-specific = Concentration of chemical in sediment (mg/kg, dry weight, maximum from Table)
PDS = 0.082 = Proportion of diet composed of sediment (dry weight basis, from Table)
WIR = 0.1382 = Water ingestion rate (L/day, from Table)
WCx = Chemical-specific = Concentration of chemical in water (mg/L, maximum from)
BW = 3.56 = Body weight (kg wet weight, minimum from Table)

$$HQ = \frac{DI_x}{\text{Screening Value (from Table)}}$$

TABLE B-10
Semipalmated Sandpiper
Comparison of Semipalmated Sandpiper Exposure Doses to Toxicity Reference Values

Chemical	Sediment Concentration	Sediment - Invertebrate BAF	Aquatic Invertebrate Concentration	Surface Water	Dietary Intake	NOAEL TRV	LOAEL TRV	NOAEL HQ	LOAEL HQ
Arsenic	23.19	0.127	2.945348633	0	0.44998382	NA	2.24	<1	<1
Acenaphthene	9.91	0.301	2.983266766	0	0.45577687	7.10	71	<1	<1
Acenaphthylene	1.31	0.301	0.394009	0	0.06019582	7.10	71	<1	<1
Anthracene	4.80	0.301	1.443481895	0	0.22053196	7.10	71	<1	<1
Benzo(a)anthracene	6.72	0.301	2.022883913	0	0.30905171	7.10	71	<1	<1
Benzo(a)pyrene	6.01	0.301	1.809913	0	0.27651449	7.10	71	<1	<1
Benzo(b)fluoranthene	5.74	0.301	1.726837	0	0.26382232	7.10	71	<1	<1
Benzo(g,h,i)perylene	2.94	0.301	0.885542	0	0.13529114	7.10	71	<1	<1
Chrysene	6.00	0.301	1.805097	0	0.27577871	7.10	71	<1	<1
Dibenz(a,h)anthracene	1.11	0.301	0.333207	0	0.05090663	7.10	71	<1	<1
Fluoranthene	16.86	0.301	5.075941457	0	0.77549106	7.10	71	<1	<1
Fluorene	19.61	0.301	5.90261	0	0.90178764	7.10	71	<1	<1
Indeno(1,2,3-cd)pyrene	2.96	0.301	0.892164	0	0.13630283	7.10	71	<1	<1
Phenanthrene	18.42	0.301	5.54437457	0	0.84705723	7.10	71	<1	<1
Pyrene	13.78	0.301	4.147716579	0	0.63367892	7.10	71	<1	<1
Total PAHs	123.5	0.301	37.1735	0	5.67928472	7.10	71	<1	<1

$$DI_x = \frac{\sum(FIR)(FC_{xi})(PDF_i) + [(FIR)(SC_x)(PDS) + [(WIR)(WCx)]}{BW}$$

DI = Chemical-specific = Dietary intake for chemical (mg chemical/kg body weight/day)
FIR = 0.0055 = Food ingestion rate (kg/day dry weight, from Table)
FCxi = Chemical-specific = Concentration of chemical in food item (fish, mg/kg, dry weight basis)
PDFi = 0.7 = Proportion of diet composed of food item (benthic inverts, dry weight basis, from Table)
SCx = Chemical-specific = Concentration of chemical in sediment (mg/kg, dry weight, maximum from Table)
PDS = 0.3 = Proportion of diet composed of sediment (dry weight basis, from Table)
WIR = 0.0059 = Water ingestion rate (L/day, from Table)
WCx = Chemical-specific = Concentration of chemical in water (mg/L, maximum from)
BW = 0.0252 = Body weight (kg wet weight, minimum from Table)

$$HQ = \frac{DI_x}{\text{Screening Value (from Table)}}$$

TABLE B-11
Black Duck
Comparison of Black Duck Exposure Doses to Toxicity Reference Values

Chemical	Average Soil Concentration (mg/kg)	Sediment - Pant BCF	Aquatic Plant Concentration	Sediment - Invertebrate BAF	Aquatic Invertebrate Concentration	Surface Water	Dietary Intake	NOAEL TRV	LOAEL TRV	NOAEL HQ	LOAEL HQ
Arsenic	23.19	0.038	0.881	0.127	0.111923248	0	0.046	NA	2.24	<1	<1
Acenaphthene	9.91	--	0.001	0.301	0.000162456	0	0.016	7.10	71	<1	<1
Acenaphthylene	1.31	--	0.003	0.301	0.000918263	0	0.002	7.10	71	<1	<1
Anthracene	4.80	--	1.261	0.301	0.379445292	0	0.030	7.10	71	<1	<1
Benzo(a)anthracene	6.72	--	0.207	0.301	0.062286383	0	0.015	7.10	71	<1	<1
Benzo(a)pyrene	6.01	--	0.732	0.301	0.220232975	0	0.023	7.10	71	<1	<1
Benzo(b)fluoranthene	5.74	0.31	1.778	0.301	0.53531947	0	0.041	7.10	71	<1	<1
Benzo(g,h,i)perylene	2.94	--	1.412	0.301	0.425074896	0	0.030	7.10	71	<1	<1
Chrysene	6.00	--	0.193	0.301	0.058208699	0	0.013	7.10	71	<1	<1
Dibenz(a,h)anthracene	1.11	0.13	0.144	0.301	0.04331691	0	0.004	7.10	71	<1	<1
Fluoranthene	16.86	0.50	8.432	0.301	2.537970728	0	0.177	7.10	71	<1	<1
Fluorene	19.61	--	0.000	0.301	9.06101E-05	0	0.032	7.10	71	<1	<1
Indeno(1,2,3-cd)pyrene	2.96	0.11	0.326	0.301	0.09813804	0	0.011	7.10	71	<1	<1
Phenanthrene	18.42	--	5.159	0.301	1.552792454	0	0.122	7.10	71	<1	<1
Pyrene	13.78	0.72	9.921	0.301	2.986355937	0	0.199	7.10	71	<1	<1
Total PAHs	123.5	--	13.934	0.301	4.194147549	0	0.450	7.10	71	<1	<1

$$DI_x = \frac{\sum(FIR)(FC_{xi})(PDF_i) + [(FIR)(SC_x)(PDS) + [(WIR)(WCx)]}{BW}$$

DI = Chemical-specific = Dietary intake for chemical (mg chemical/kg body weight/day)
FIR = 0.0657 = Food ingestion rate (kg/day dry weight, from Table)
FCxi = Chemical-specific = Concentration of chemical in food item (plants, mg/kg, dry weight basis)
PDFi = 0.047 = Proportion of diet composed of food item (plants, dry weight basis, from Table
FCxi = Chemical-specific = Concentration of chemical in food item (invertebrates, mg/kg, dry weight basis
PDFi = 0.92 = Proportion of diet composed of food item (invertebrates, dry weight basis, from Table
SCx = Chemical-specific = Concentration of chemical in soil (mg/kg, dry weight, maximum from Table)
PDS = 0.03 = Proportion of diet composed of soil (dry weight basis, from Table
WIR = 0.0668 = Water ingestion rate (L/day, from Table)
WCx = Chemical-specific = Concentration of chemical in water (mg/L, maximum from)
BW = 1.2 = Body weight (kg wet weight, minimum from Table)

$$HQ = \frac{DI_x}{\text{Screening Value (from Table)}}$$

Appendix C
Data Quality Objectives

Data Quality Objectives

The following section presents an overview of the BERA investigation through a discussion of the Data Quality Objectives (DQOs) that have been developed for this investigation. The DQOs presented in this section were developed according to the seven step process established in EPA guidance (2006) and provide a detailed description of the planned BERA investigation.

Step 1. State the Problem

The objective of the BERA investigation is to collect the additional data that are necessary to fully characterize ecological risk for the assessment endpoints identified for evaluation in the ERA. Ecological risk screening (Appendix B) conducted with sediments data collected during the RI (CH2M HILL 2007) indicate a minimal potential for risk to avian and mammalian wildlife and suggest that additional data are not necessary to characterize risks to these receptors. Available sediment data were also used to screen the potential for risk to fish populations. This screen also suggests a minimal potential for adverse effects to fish from the presence of PAHs in sediment. However, as discussed in Section 3.2, further consideration of the fish endpoint is ongoing and a Technical Memorandum presenting a revised approach with technical justification will be submitted to USEPA and BTAG members for consideration. Once an approach is agreed upon, the work plan and DQOs will be revised, as necessary, to reflect the final approach.

A screen of the available sediments data, coupled with the USEPA (2000) ERA, suggests there is some potential for adverse effect to benthic organisms. This potential for adverse effect occurs primarily in the area immediately adjacent to the bulkhead, where the highest PAH concentrations were detected. However, there are several uncertainties associated with the estimate of risk. Perhaps most notably, the bioavailability of chemicals in sediment has not been fully characterized. Literature-based toxicity values frequently overestimate the potential for adverse effects to benthic organisms, by not fully accounting for the bioavailability of chemicals in sediments. Further, the spatial extent of the potential toxicity has not been fully characterized. The USEPA (2000) bioassays suggest a minimal potential for adverse effects to benthic organisms beyond the area immediately adjacent to the bulkheaded shoreline. Although the results of the ESBTU screening completed using the RI data (see Appendix B) are consistent with the USEPA (2000) outcomes, this broader chemical analysis does not fully characterize risk to benthic-dwelling organisms. Additional measures of potential impact to benthic organisms that more directly account for the bioavailability and the cumulative effect of chemicals in sediment are needed as additional supporting lines of evidence to fully evaluate potential risk to the benthic community. Additionally, risk to the benthic community in potentially site-impacted areas relative to nonsite-impacted areas has not been adequately characterized.

A BERA investigation will be conducted to further build on the existing database in order to fill the key data gaps, reduce uncertainty, and facilitate a more detailed characterization of potential site-related risks to the benthic community. The BERA investigation will develop

multiple lines of evidence and use a weight of evidence approach to further characterize ecological risk to the benthic community. General data types that will be collected to achieve the objectives of the BERA investigation consist of the following:

- Sediment bioassay;
- Benthic community composition;
- Chemical concentrations in surface sediment, sediment pore water; and,
- Sediment physical attributes.

A description of the data to be collected as part of this further investigation is presented in Step 5 of the DQO discussion and Sections 4 and 5 of the work plan. Once the investigation is completed, the additional data collected as part of the BERA investigation will be used in conjunction with applicable data collected from earlier investigations to characterize the overall potential for adverse effects to ecological receptors and complete Step 7 of the ERA.

Step 2. Identify the Goals of the Study

The goal of the ERA is to evaluate each of the assessment endpoints identified for evaluation and address the following principal questions:

- Are site-related chemicals impacting the viability of the benthic invertebrate community structure and function?
- Are site-related chemicals impacting the viability of fish populations (with emphasis on essential fish species)?
- Are site-related chemicals impacting the viability of avian and/or mammalian wildlife?

As already discussed, the preliminary screening of ecological risks indicates that adequate data have been collected during the initial ERA (USEPA 2000) and during the RI (CH2M HILL 2007) to characterize risks to avian and mammalian wildlife. Furthermore, the preliminary evaluation of risks to fish populations (see Section 3.2) suggests a minimal potential for adverse effect. Accordingly the focus of the BERA investigation will be on collecting the additional data that, when used in conjunction with existing data, can be used to fully evaluate potential risks to the benthic invertebrate community. The additional evaluation of risk to benthic organisms is accordingly the primary focus of the DQO Step 2 discussion.

The principal question for the evaluation of risk to the benthic community can be most fully addressed by using the BERA data to answer a series of smaller component questions which, when considered together, answer the principal BERA study question:

- Are there risks to the benthic community?
- Are the observed risks site-related?
- What is the spatial extent/pattern of site-related risk to the benthic community?
- Do risks differ between site-impacted and reference areas?
- To what chemical or physical factor(s) can impacts be attributed?

The objective of the BERA is to collect the additional data necessary to address each of these component questions. The following sections provide a description of the data that will be

collected to evaluate risks to each of the receptors identified for evaluation, with emphasis on the continued collection of data for the evaluation of risks to the benthic community.

Step 3. Identify Information Inputs

Step 7 of the ERA will consider all data that are relevant to the final evaluation of risk to ecological receptors. Data from all applicable investigations will be used to evaluate the potential for adverse effects to ecological receptors. In addition to the data that will be collected during the BERA investigation, the ERA will include evaluation of data from the following investigations:

- USEPA ERA Site Investigation conducted in May, 2000
- RI conducted October through December, 2006
- Groundwater - Surface Water Investigation planned for Summer, 2008

As discussed, the primary objective of the BERA investigation will be to collect the additional data necessary to evaluate potential risks to the benthic community. The additional data to be collected during the BERA investigation consist of the following:

- Chemical analytical and physical data for surficial (0 to 6 inches) sediment and pore water samples collected from OU2 and upriver locations.
- Benthic invertebrate (Leptocheirus plumulosus) bioassay data for sediment samples collected from OU2 and upriver locations.
- Benthic community analysis samples collected from OU2 and upriver locations.

Table C-1 summarizes the specific data from each of the site investigations that will be used to evaluate risks to the receptors identified for evaluation in the ERA. Table C-2 summarizes how the data to be collected during the BERA investigation will be used to answer each of the main questions associated with the benthic community. The following sections provide a more detailed discussion of the study area boundaries and the data to be collected during the BERA investigation.

Step 4. Define the Boundaries of the Study

The targets for the BERA investigation study are surficial sediment (0 to 6 inches) in OU2 Areas A and B and in an upriver area that has not been affected by past releases from OU1 and pore water and surface water in areas that may have been affected by groundwater releases from OU1.

Sediment sample data collected during the USEPA ERA investigation (USEPA 2000) and during the RI (CH2M HILL 2007) indicate that PAH concentrations are highest immediately adjacent to the bulkhead, with concentrations rapidly decreasing to levels approximating those detected in upriver/downriver sediments with increasing distance from the shoreline. Arsenic concentrations, meanwhile, are elevated in two highly localized areas: at the northern edge of the gypsum landfill and along the shoreline south of 115 River Road. The distribution of PAHs (total) and arsenic, which where characterized during the RI (CH2M HILL 2006) is shown in Figures 4-1 and 4-2, respectively. Concentrations of most

other chemicals detected in sediment during the RI appear to be uniformly distributed throughout the OU2 area at similar concentrations to those detected in upriver and downriver sample locations and, as discussed in the RI (CH2M HILL 2007), these other chemicals do not appear to be site-related.

A primary objective of the BERA investigation is to characterize risk to benthic organisms associated with the full range of site-related chemical concentrations and compare those with risks to benthic organisms occurring in areas that have not been affected by the site. Based on the distribution of PAHs and arsenic in sediment, the study area for OU2 will be bounded on the west by the shoreline and will extend approximately 630 feet to the east in order to fully characterize risks within the potentially site-impacted areas and potential risks within immediately adjacent areas which have not been impacted by site activities.

The study will include sediment samples collected from an upriver area extending from approximately 1,500 feet north of the OU2 boundary to a location just north of the George Washington Bridge. These upriver samples will be collected at locations along the western shore of the river in an area that was sampled during the RI and that appears to be physically similar to the Site, but that has not been impacted by the site.

Sediment samples will be collected to a depth of 0.5 feet. This sample depth is expected to capture the zone in which most ecological receptors would be expected to occur within this estuarine habitat. Based on the benthic community surveys and the habitats present onsite (see Appendix A), few ecological receptors are expected to occur in sediments at a greater depth.

Step 5. Develop the Analytic Approach

The OU2 sample locations were selected based primarily on the distribution of PAHs (characterized during the RI; Figures 4-1 and 4-2, respectively) and results of the risk screening calculations (Appendix B). As already discussed, the primary objective of the BERA investigation will be to collect the additional data that are needed to fully characterize site-related risk to the benthic community. In order to characterize potential risks, ten discrete sediment samples will be collected from the OU2 Area. Two samples (see Figure 5-1) will be collected from locations immediately adjacent to the bulkhead, at locations that were determined during the RI (CH2M HILL 2007) to have some of the highest PAH concentrations, and the greatest potential for PAH risk to benthic invertebrates, as determined by PAH ESBTUs (Appendix B). Eight samples will be collected from locations distributed throughout the remaining portions of Areas A and B. PAH ESBTU values in this area are less than 5.0 (see Figure 5-1), suggesting a limited potential for risk to mostly sensitive species. In addition to the OU2 area samples, ten reference sediment samples will be collected from stations that range from approximately 1,500 feet north of OU2 to just north of the George Washington Bridge (see Figure 5-2). These locations were selected as reference samples for the BERA investigation based on a review of the RI (CH2M HILL 2007) reference sample data, which indicates they have similar physical characteristics to the sediments in the OU2 area and that they have not been impacted by localized sources of contamination. PAH ESBTUs at these stations are below 1.0 and arsenic concentrations are below the PEC (Appendix B).

Risks to the benthic invertebrate community will be evaluated in the BERA using three primary measures: the *L. plumulosus* 28-day sediment bioassay, benthic community analyses, and sediment and pore water chemical analyses. These analyses will be conducted on all sediment samples collected during the BERA and the lines of evidence will be used as part of a multi-parameter weight of evidence approach to evaluate the overall potential for adverse effects to the benthic community. Section 4 of the work plan provides a detailed description of the approach that will be used to collect and analyze these data.

The above analysis will provide information that will be used to determine if there are risks to benthic organisms, if those risks are site-related, and if there are significant differences between risks in the OU2 and reference areas. If a potential for adverse effects is indicated, then additional analyses will then be conducted to characterize the variable likely to be causing the observed effect. In addition to further evaluating risks to the benthic community, the data collected during the BERA investigation will be used to confirm the wildlife food web model outcomes. It is expected this confirmation will primarily involve comparing sediment chemical concentrations detected during the BERA investigation with those detected in sediment during earlier investigations to ensure that chemical concentrations and the potential for risk to wildlife would not significantly change with consideration of the additional data. If the chemical analytical data indicates significantly higher chemical concentrations, then risks to wildlife will be recalculated using the same approach as described in Appendix B for the food web model risk calculations. As previously discussed, the need for further evaluation of the potential for adverse effects to fish populations is currently under evaluation. Once an approach is agreed upon, the work plan and DQOs will be revised, as necessary, to reflect the final approach that will be taken for the evaluation of this endpoint.

Step 6. Specify Performance Criteria

Performance criteria are established to ensure both the overall quality of the collected data and to ensure these data will support the underlying evaluation and conclusions made in the ERA. Performance criteria for this BERA investigation have been incorporated into the discussion of the field and laboratory investigation (Section 5) and will be included in the Field Sampling Plan and Quality Assurance Project Plan for the BERA investigation.

Step 7. Develop the Plan for Obtaining the Data

The approach used to collect analytical data for the USEPA ERA investigation and RI are summarized in USEPA (2000) and CH2M HILL (2007). Sediment sampling for the BERA bioassay, benthic community, and chemical/physical analyses will be conducted concurrently. Sediment samples (0 to 6 inches) will be collected with a grab sampler and dispensed directly into individual holding containers. Duplicate grab samples will also be collected from two randomly selected sample locations. Multiple grab samples will be taken to collect adequate samples for analysis. The multiple grab samples will be placed into a single container, immediately homogenized, and then split for sediment chemistry and bioassay analyses. Samples for benthic community analysis will be collected immediately adjacent to the locations from which the sediments for bioassay and sediment chemical analysis are collected.

References

CH2M HILL. 2007. Draft Preliminary Site Characterization Operable Unit 2 Quanta Resources Superfund Site Edgewater, New Jersey.

U.S. Environmental Protection Agency (USEPA). 2000. Final Report Ecological Risk Assessment, Quanta Resources Site, Edgewater, New Jersey. August.

TABLE C-1
Summary of Data to Be Used for the Evaluation of Ecological Risk

Investigation	Data Available		Data Use in Baseline Ecological Risk Assessment		
	Type	Available/Planned Data	Evaluation of Risks to Benthic Community	Evaluation of Risks to Wildlife	Evaluation of Risks to Fish
EPA (2000) ERA Investigation	Surface sediment (0 to 6 inches) chemical/physical analyses	Six locations from Area A	X	X	X
	Leptocheirus plumulosus 14 day sediment bioassay on surface sediment samples	Six locations from Area A	X		
	Benthic community analyses	Six locations from Area A	X		
	Menidia beryllina 7 day solid phase sediment bioassay on surface sediment samples	Six locations from Area A			X
CH2M HILL (2006) RI	Surface sediment (0 to 6 inches) chemical/physical analyses	46 locations from Area A; 27 locations from Area B; 20 upriver/downriver locations	X	X	X
Planned (Summer 2008) Groundwater-Surface Water Investigation	Sediment pore water collected with Trident Proble for chemical analysis	Five locations	X		X
	Surface water for chemical analysis	Collected from same locations as sediment pore water			X
Planned (Fall 2008) BERA Investigation	Surface sediment (0 to 6 inches) chemical/physical analyses	8 locations from Area A; 2 locations from Area B; 10 upriver/downriver locations	X	X	X
	Sediment pore water collected for PAH ID-SPME analysis	8 locations from Area A; 2 locations from Area B; 10 upriver/downriver locations	X		X
	Leptocheirus plumulosus 28 day sediment bioassay on surface sediment samples	8 locations from Area A (including 2 dilution series samples); 2 locations from Area B; 10 upriver/downriver locations	X		
	Benthic community analyses	8 locations from Area A; 2 locations from Area B; 10 upriver/downriver locations	X		

TABLE C-2
Application of Data to the Evaluation of Benthic Community Risks

	Analyses										
	Sediment Bioassay			Benthic Community			Sediment Chemical				
Question	Comparison of site samples to lab control	Spatial Analysis	Comparison of site samples to reference	Comparison of site samples to diversity/abundance measures	Spatial trends in diversity/abundance	Comparison of site sample diversity/abundance to reference	Comparison of detected chemical concentrations to literature screening values	Spatial Analysis	Comparison of site sample concentrations to reference	ID-SPME method to measure dissolved PAHs in pore water	Comparison of trends in chemical concentrations/physical attributes with bioassay outcomes and benthic community composition
Are there risks to the benthic community?	X	X		X	X		X	X		X	
Are the observed risks site-related?		X	X		X	X		X	X		
Do risks differ between site-impacted and reference areas?			X			X			X		
What is the spatial extent/pattern of risk to the benthic community?		X			X						
To what chemical(s) and/or physical factor(s) can impacts be attributed?										X	X